COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

PR

May, 1949

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White River Generating Station of Indianapolis Power & Light Co.

Slagging-Bottom Furnaces Abroad

Report of Midwest Power Conference

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DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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FOR MAY 1949

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EDITORIAL

Will There Be A Coal Strike?

This is the season for perennial interruptions in coal supply, when contracts between the operators and miners come up for renegotiation. Can it be that this year will prove an exception?

From some accounts, it would appear that Mr. Lewis may be in a more cooperative mood than formerly, as indicated by his willingness to meet separately with the southern coal operators; although, at this writing, his demands have not been disclosed.

If this be true, several factors may account for a modified attitude. The new labor bill did not go through as scheduled and Mr. Lewis undoubtedly has unpleasant recollections of Judge Goldborough's actions under the injunctive provisions of the Taft-Hartley Law, and a coal stoppage at this time would certainly strengthen a popular demand for teeth in the new law.

Another plausible reason is that coal stocks at present are in a satisfactory state, the two-week suspension, which Mr Lewis ordered early this spring, having made only a small dent in the coal on hand among utilities and industrials. Now with a drop in the curve of electrical output and the strong competitive position of oil, a stoppage in coal deliveries would be less effective in forcing compliance with unreasonable demands of the miners. Mr. Lewis knows this full well; also that any action resulting in a further substantial increase in coal prices would drive more plants to competitive fuels and thus react adversely against employment of miners.

Perhaps there may be something to the rumor concerning a more conciliatory attitude. The next few weeks will tell the story.

Marine Fouling

Dangers of generalizing conclusions regarding marine fouling were emphasized at a session sponsored by the Power Division at the Spring Meeting of the A.S.M.E. To apply a solution that is successful under one set of conditions to another situation is to invite trouble, unless steps are taken to investigate the similarities and differences involved. This is especially true when dealing with biological organisms which have the ability to make certain adaptations to changing physical conditions.

To those unfamiliar with problems encountered in marine fouling it is paradoxical to note that steps to minimize harbor pollution aggravate marine fouling problems. A corollary is that less difficulty is experienced from this type of fouling in contaminated water than in clean water.

Intake tunnels for circulating condensing water are an important part of steam plant operation. Any condition which tends to block these tunnels is a potential cause of station outage. If this same condition also results in difficult and unfavorable working conditions when periodical manual cleaning is required, it becomes a threat to good personnel relations. The individuals who conducted the studies and the companies which sponsored them deserve credit for the progress that has been achieved in overcoming some of the most troublesome marine fouling problems. An indication of the importance and excellence of the papers is that they are to be summarized at the Semi-Annual Meeting of the A.S.M.E. to be held in San Francisco from June 27 to July 1.

Desirable Personal Characteristics

The Engineers Council for Professional Development has been credited with numerous useful studies in the field of engineering, along educational, technical and economic lines. Now the results have been announced of a survey dealing with human attributes, that is, "The Most Desirable Personal Characteristics," as indicated by replies from more than a thousand respondents to a questionnaire, who included business executives, personnel directors, educators and students.

Of six carefully selected personal characteristics, all groups, but not all individuals, placed intelligence in first place, and physical attributes last. Between these extremes dependability, organizational acceptability, energy and emotional acceptability rated in order in the overall picture.

However, aside from intelligence, which was generally accepted as meaning clear thinking, there was considerable divergence in interpretation of the other characteristics, particularly as viewed by the several groups reporting. While intelligence and dependability topped the list with reference to research and design, in the field of management and production the margin over other qualities was less; and as concerns sales and distribution, dynamic personality and physical acceptance moved to first and second places, respectively, with some differential as to the type of product involved.

As the Committee points out, the survey is to be regarded only as a "rough measurement in a rugged terrain," the primary objective being educational rather than operational; although employers of technical and professional help will find it of interest, particularly the numerous charts contained in the report.

New 160,000-Kw WHITE RIVER GENERATING STATION of Indianapolis Power & Light Co.

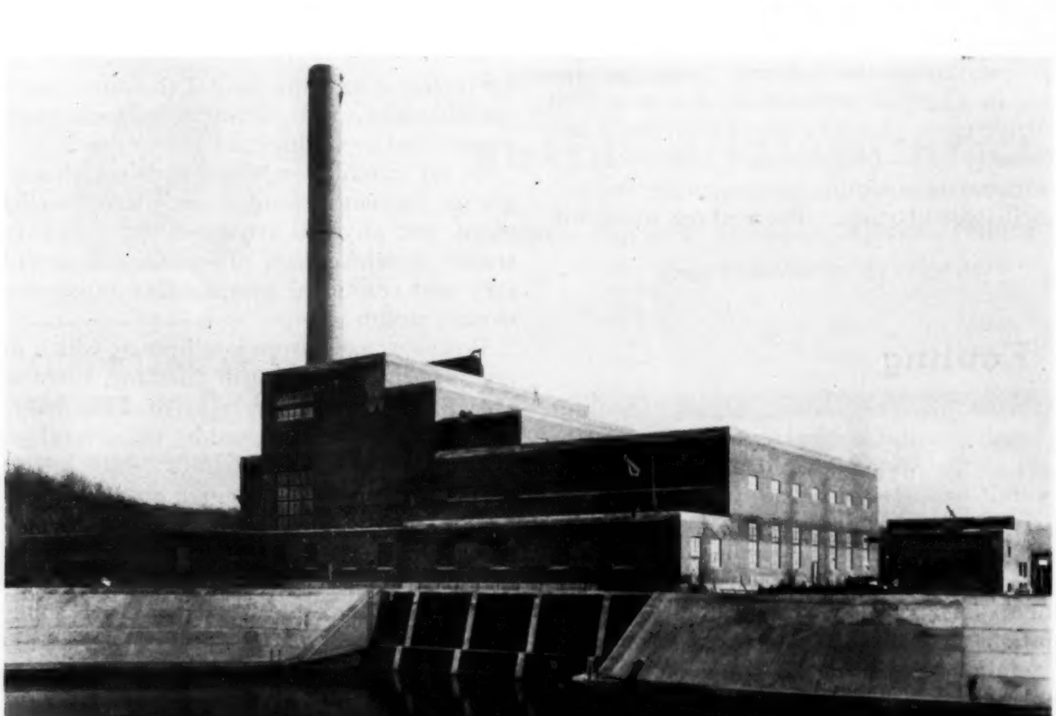
Laid out for an ultimate capacity of 160,000 kw, the first 40,000-kw unit of this new station is now in service and the second on order. Steam conditions are 850 psi, 900 F at the turbine throttle, and the 400,000-lb per hr boiler is equipped with a slagging-bottom furnace. The anticipated station heat rate is 11,537 Btu per kwhr and the total cost of the first 80,000-kw capacity, including site, step-up substation and all facilities, will be approximately $152 per kw nameplate rating.

By A. A. BENSON
Plant Design Engineer,
Indianapolis Power & Light Co.

THE first 40,000-kw generating unit, No. 1, of the new White River Station of the Indianapolis Power & Light Company, Indianapolis, Indiana, was synchronized on February 23, 1949, just four months after receipt of first turbine shipment. Ground was broken for the station on June 18, 1947, and a total of 20 months and 5 days were required for construction. High water early in 1948 caused 6 weeks' delay in construction.

This new station will have an ultimate capacity of 160,000 kw and will consist of four 40,000-kw units. The initial project just completed provides building space also for Unit No. 2 which is now on order and which is scheduled for operation in April of 1950, slightly over a year after Unit No. 1 went into service. The third unit, now on order, is scheduled for operation by December 1951. The final cost of the first two units including grounds, step-up substation and all facilities will approximate $12,160,000, or $152 per kw nameplate rating.

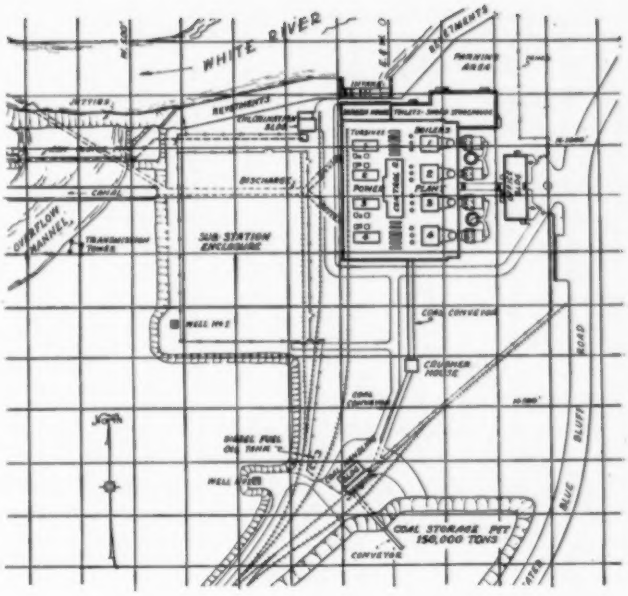
Before adding this new station, the total capacity of the system, which serves Indianapolis and practically all of Marion County, was 259,000 kw (nameplate rating). Of this capacity, 110,500 kw was installed in three old plants within the city of Indianapolis and the balance of 148,500 kw in the Harding Street Station $4\frac{1}{2}$ miles southwest of the city, just outside the city limits. Harding Street Station was the main base load station. It has two 36,750-kw, 400-psi, 750-F units, No. 1 and No. 2,



Power station as seen from north side of river

installed in 1931; one 37,500-kw, 850-psi, 900-F unit, No. 3, installed in 1941; and one 37,500-kw, 850-psi, 900-F unit, No. 4, installed in 1947. These last two units, each of which includes a 400,000-lb. per hr Combustion Engineering boiler, performed so satisfactorily that their principal features were used as a guide in the design of the new White River Station.

The need for a new station was anticipated during 1943 and routine temperature readings of the White River were taken downstream from our Harding Street plant to determine how far downstream the temperature was reduced, by dilution, evaporation, and ground cooling, to suitable circulating water temperatures. These readings indicated the need for locating the new plant at least 15 miles downstream from Harding Street. The river flows indicated circulating water available for 160,000 kw if some recirculation was allowed during exceptionally dry years. During the summer of 1946 appropriations were made for the new station; turbine-generator No. 1 was ordered, and Gibbs & Hill, Inc., Pennsylvania Station, New York 1, N. Y., were retained as engineers to design and supervise construction.



General plan of plant area

Site and Building Features

A suitable site was selected in Morgan County, eighteen miles southwest from the city limits of Indianapolis and 4 miles due north of Martinsville. About 600 acres of land, located on both sides of White River and traversed by the Pennsylvania Railroad (Vincennes Division), were purchased for the station site. River bank protection, consisting of 1950 lineal feet of No. 416 Kellnar Jetties, was installed early in 1947 to keep the river in its channel, as it was eating away the bank very rapidly at a point where circulating water intake was to be located. Practically all the land was corn field, and it was necessary to fill the station building area with a fill 8 to 10 ft deep to bring finished grade up to elevation 616 ft (3 ft above the 1913 flood level of 613 ft—the highest ever recorded). Good gravel fill was obtained from excavations made for the coal-storage pit and main building foundations, and some dredging of the river. For the first two units circulating water will be discharged about 600 ft downstream from the plant via a 6-ft concrete pipe. With the addition of Unit No. 3 a dam will be built approximately 3200 ft downstream, and a canal will carry circulating water under the railroad track to be discharged below the dam with provisions for recirculating.

A railroad siding 2427 ft long was installed along the Pennsylvania Railroad main tracks, and from this siding 7300 ft of 100-lb relayer rail trackage was laid onto the station property. This arrangement provides for the storage of 113 coal cars on two tracks initially, and 170 coal cars ultimately by adding one more track.

The new station buildings were designed without frills, but substantial and at the lowest cost practical under the existing high costs of construction. To keep operating personnel at a minimum, the intake screens and circulating pumps were located in the turbine room; all major equipment possible was located on the operating floor (elevation 619 ft), and a control room was centrally located for control of equipment for all four units. To operate the first unit 53 men are required and after extension to the ultimate four units, a total of 88 men will be required. When comparing this with the 147 men required to operate our four-unit Harding Street Station, it is evident that very considerable improvement has been accomplished.

The steel, concrete and brick power plant building is located close to the south bank of the river where over 600 ft of protecting concrete revetment sloping 30 deg was installed. Foundations consist of heavy reinforced concrete slab under the entire structure, without piling. The turbine room is located on the west side of the building and boilers on the east side, with no dividing wall. Screen house, locker room, shops and storeroom are located on the north end of building at the permanent end. Brick stack and induced-draft fans are located outside the east wall of the building. The chlorine building for circulating water desliming and the step-up substation are located to the west, and coal-unloading facilities to the south. A separate one-story office building, situated east of the plant and facing on Blue Bluff Road, provides for the chief engineer, supervisors, laboratory, first-aid room, recreation room with kitchen, and telephone equipment.

The building for Units No. 1 and No. 2 extends 15 ft south of the office centerline, and the south wall of the plant is of temporary low-cost asbestos board construction. The limited interior decorative features consist of clear glazed wall tile and green-colored scored concrete floors for turbine room, locker and shower room, with salt-glazed tile in the balance of plant. Outside trim is Indiana limestone and Martinsville red brick.

Ventilation of the main power plant is achieved in a new and unique way that will practically eliminate the high draft which exists in most plants during the winter and makes the opening of outside doors difficult. A series of inlet louvers arranged just above the operating floor on the east and west sides of the building allow all air to enter and flow below the operating floor to the basement by ducts. These ducts have fin-type heaters which heat all incoming air from 0 F to a minimum of 40 F. The air flows through the basement, keeping it dry, and rises through grating openings in floors, around equipment, and through open hatchways, eventually rising to a high point above the boilers where suction ducts draw it

down to the inlet of forced-draft fans enclosed in rooms located on the operating floor. In addition, there are unit heaters or blower heaters to maintain comfort in working areas. For summer ventilation a generous number of fan-type roof ventilators will exhaust the accumulation of hot air; and since all window sashes are of the pivoted ventilating type, additional air in excess of that required by the forced-draft fans is admitted.

Equipment Selection

In selecting equipment, the excellent results obtained on Units 3 and 4 at Harding Street Station practically set the steam conditions of 850 psig, 900 F, at the throttle. Considerable time was saved on preliminary engineering by duplicating the Harding Street turbines, boilers and certain other equipment. Later studies were made for the second and third units to see if 850 psi, 950 F; 1250 psi, 950 F; or 1450 psi, 1000 F—reheat 1000 F was justified by the higher prices of coal. However, these studies confirmed the original selection of 850 psi, 900 F. Emphasis was placed on the selection of equipment which had proved reliable and satisfactory either in our own system or at other plants.

To avoid costly and confusing cross-connections of piping and wiring, each boiler and turbine-generator with necessary auxiliary equipment and switchgear is arranged on the unit basis. Auxiliaries have been designed amply for maximum load conditions; although, in the event of a complete failure of any major auxiliaries, the unit would be shut down.

For the turbine room a 25-ton crane was chosen as suitable for regular maintenance instead of a heavy and more costly crane suitable for handling the 104-ton generator during erection. With the railroad track arranged the full length of the west side of the turbine room, the No. 1 generator stator was jacked up and rolled onto its foundation at the remarkably low overall total cost of $1800.

A complete study was made into the demineralization process of treating makeup water to effect economies in boiler blowdown and chemicals and in operating attendance, and to eliminate the need for an evaporator. However, for our normal makeup requirements of about one per cent it was found that the total first cost of demineralization equipment was not justified. Final selection of makeup well-water treating equipment consisted of a 6000-gph hot-process lime-soda softener designed for the four-unit plant, but with filters omitted until installation of the third unit and 12,000-lb per hr unit evaporators operating with turbine-extraction steam. Also, phosphate and santosite pumps supply shot-feed of these chemicals directly to boiler drum.

The coal scales were omitted in the boiler room at a considerable saving in first cost and later maintenance. Furthermore, the coal bunkers could be lowered, resulting in a reduction in a portion of building height from which a saving on building costs also resulted.

Automatic soot blowers, both of the steam and air-puff type, were considered, but their additional cost could not be justified; furthermore, the auxiliary operators when hand operating soot blowers supplied necessary periodic inspection of the boiler.

Boilers and Auxiliaries

A Combustion Engineering 3-drum steam generator of 400,000 lb per hr continuous capacity at 875 psig, 900 F, with an overall efficiency of 85.44 per cent supplies each unit. The furnace is of the wet-bottom type having three tangentially fired, type TV tilting burners located just above the operating floor at each corner. These are

Cross-section through power house

supplied by three C-E Raymond No. 533A bowl mills, each having a capacity of 21,600 lb per hr when pulverizing Indiana strip mine coal having a Hardgrove grindability of 55 and pulverizing to a fineness of 75 per cent through 200-mesh screen. Full load can be carried on the turbine with only two mills in service, although the third mill insures maximum output with poor grades of coal or storage coal which is burned during coal shortages. Furthermore, the use of three burners per corner should permit better combustion with one mill at low loads, and with three mills at maximum loads it should aid considerably in preventing tube wastage. Burner ignition consists of two mechanical atomizing oil torches of 65 gph capacity each, located in each corner between the coal burners and designed for No. 3 fuel oil at 250 psig. A small pilot torch operating on oil atomized with compressed air and having electric ignition is located at each corner of furnace to ignite the oil torches. The boiler room auxiliary operator inserts ignition torches when starting up or coming off the line, and no automatic or remote starting equipment was provided. The turbine-generator can be synchronized and carry 5000 kw on the eight oil torches.

Steam temperature control from the Elesco two-stage interbank superheater is attained by means of a bypass damper with a Leeds & Northrup controller operating on air flow across the boiler passes and secondary correction from steam temperature. A Leeds & Northrup combustion control system and a Bailey three-element feedwater control automatically maintain adjustments of fuel, air and water for all loads. The soot blowers are of the steam type, manually operated. Suitable walkways and platforms have been provided for complete accessibility to all portions of the steam generating unit.

American Blower forced-draft and induced-draft fans, each connected to a high-speed and a low-speed motor with inlet vanes and louvers, control the flow of air and gas. Each forced-draft fan is located in a small airtight fan room on the operating floor from which a suction duct rises to a point under the roof where the hot air above the boiler is removed. Each induced-draft fan is located outside the building on foundations at ground level and is provided with totally enclosed motors having heaters in the windings to keep out moisture. One 250 ft high by 14 ft inside diameter radial brick stack handles gases from two steam generating units. The multiclone mechanical dust collector is also placed outside the east wall just before the induced-draft fan inlet. Just inside a low bay on the east side of the building is the Ljungstrom air preheater arranged so that a minimum of gas and air duct is required. This results in a substantial saving of metal and insulation. No economizers were necessary to obtain a final flue gas temperature of 338 F and, therefore, were omitted since past experience has indicated that this equipment is subject to high maintenance.

Three Ingersoll-Rand half-capacity boiler feed pumps (two motor-driven and one dual motor- and turbine-driven) are placed on the operating floor to supply each steam generator. Two pumps are operated during full load and one pump is a standby. These pumps are of the diffuser type, stainless steel fitted, and have casings cast of 5 per cent chrome steel. Automatic bypass recirculation to the deaerating heater is provided at low flows by Bailey meters and control valves.

Turbine-Generator Equipment

Each unit consists of a 40,000-kw Preferred Standard General Electric turbine-generator, 3600 rpm, tandem-compound double-flow exhaust type driving a 13,800-volt hydrogen-cooled generator, arranged crosswise of the turbine room. The turbine has 20 stages, is designed for 850 psig, 900 F at the throttle, and is provided with extraction points at the 4th, 7th, 12th, 15th and 18th stages. The separate motor-generator exciter, excitation cubicle with built-in amplidyne voltage regulator, and air ejector are all located on the main floor.

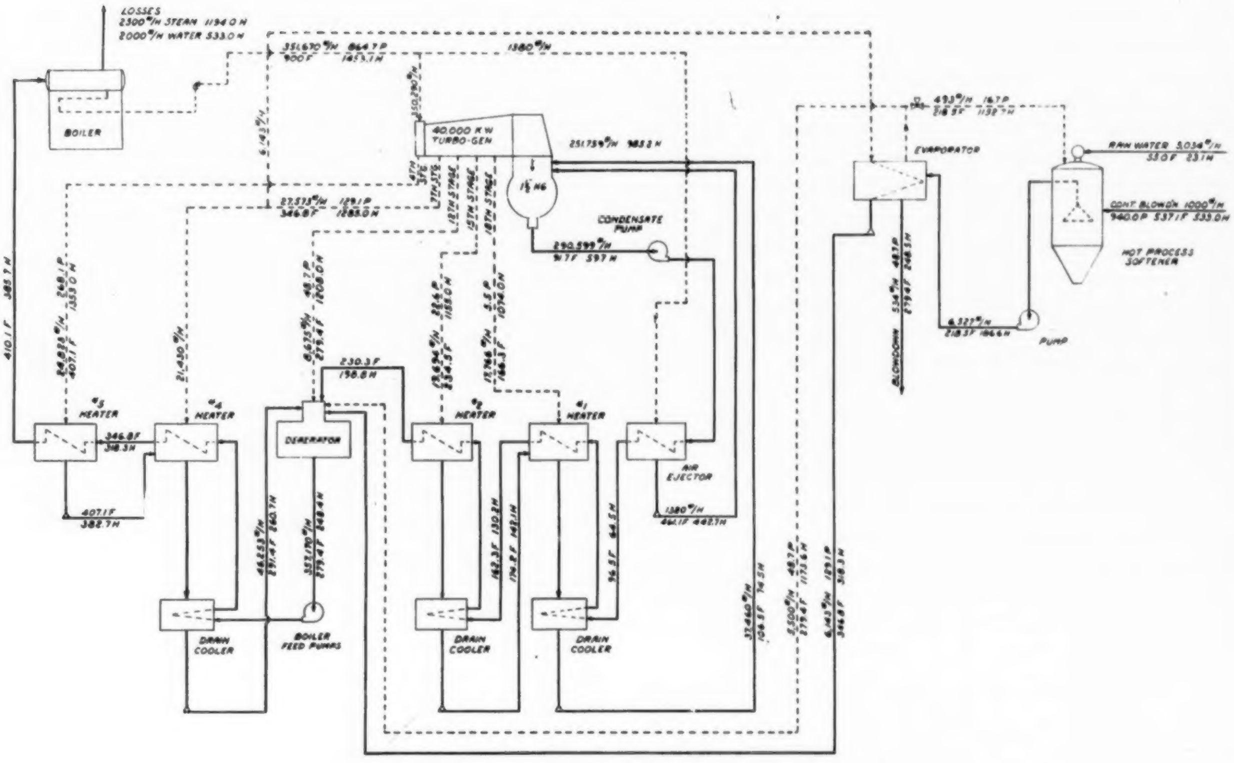
The turbine exhaust passes to a 30,000-sq ft Ingersoll-Rand condenser having $^7/_8$-in. × 22-ft tubes and divided water boxes so that half can be cleaned while in service. It is designed for low head-room with a large shallow hotwell having two minutes' condensate storage. The 23-ft height between turbine main floor and basement provided ample clearance under the hotwell, and by using two vertical condensate pumps set in 18-in. diameter wells below the basement floor, the usual condenser pit was omitted. Two 16,250-gpm, 30-ft (total discharge head) vertical mixed-flow circulating water pumps supply each condenser through a common 42-in. steel pipe under the basement floor; and a similar pipe discharges from the condenser to an outside underground concrete duct which, in turn, discharges to the river.

Feedwater Cycle

Five extraction heaters raise the condensate to its final feedwater temperature of 410 F. Heaters No. 1 and No. 2 are of the closed-shell, U-tube type operating off the 18th and 15th stages, each having a drain cooler section and with drains cascading back to the condenser hotwell. The No. 3 heater is a deaerating type supplied from the 12th-stage extraction and having a 10-min. capacity storage tank suitably baffled internally to prevent vaporization in boiler feed pump suction on sudden loss of load and drop in pressure. The 4th- and 5th-stage heaters, supplied from the 7th and 4th stages, operate on the discharge side of the boiler feed pumps and are of closed-shell, U-tube construction with desuperheating zones. The 4th-stage heater also has a drain cooler, with drains cascading to the deaerating heater. An evaporator operating off the 7th stage discharges vapor and drainage to the deaerating heater.

Surging and makeup control is accomplished by liquid-level controllers at the condenser hotwell. A 23,000-gal. condensate tank, located in the turbine-room basement near the condenser, is utilized to store up water during normal operation and supplies hotwell water during periods of starting up when boiler and superheater vents blow steam to atmosphere in excess of the makeup capacity of the evaporator. Condensate enters the deaerator through two float-actuated valves in parallel to insure positive supply of water in the event of trouble with one valve. Should the deaerator level rise, these valves automatically close, restricting the flow of condensate which raises the condenser hotwell level and brings into service the high level controller; this allows condensate to flow from the outlet of the air ejector to the condensate storage tank.

The arrangement of heaters is simple, without the use of drain pumps, and utilizes gravity flow for cascading drains to the lower pressure point of discharge. One



Flow diagram and heat balance at 40,000-kw load

6000-gph hot-process lime-soda softener receives water from the two 90-ft deep 1000-gpm gravel-packed wells and has sufficient capacity to supply the four 12,000-lb per hr evaporators of the ultimate plant.

Filters and backwash equipment were omitted on the initial installation, but provisions were made for installing them with the third or fourth unit, as required. Calculated net heat rate for the first unit at full load output of 40,000 kw is 11,537 Btu per kwhr, which figure is in line with actual operating results obtained from No. 3 and No. 4 units at Harding Street Station.

Central Control Room

The most unusual feature of this station is the centrally located control room which will eventually contain panels, instruments, and controls for completely operating four units. As evident on the main floor plan, the control panels are arranged in groups so as to allow each operator a clear view of the boiler or turbine, which is always reassuring, particularly when bringing a unit on or off the line.

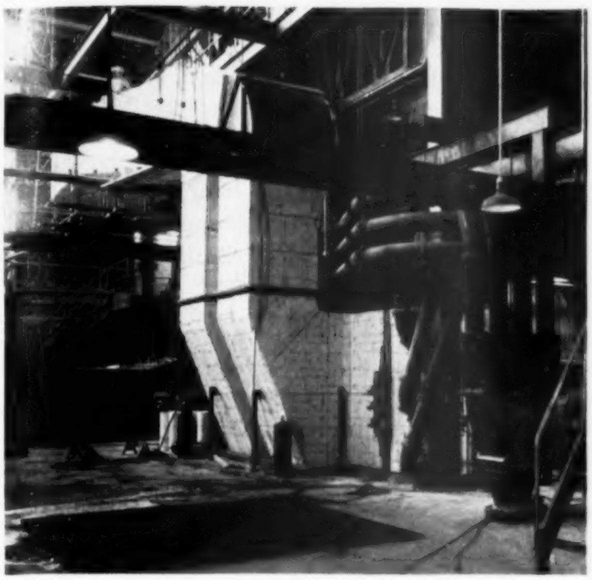
Remote indication and record of all operating flows, pressures, temperatures and liquid levels are contained on the straight-front panels, with suitable alarms to warn operators of unusual conditions when they occur. Panels A, B and C, all supplied by Leeds & Northrup Company, contain controls for one boiler with convenient grouping, for example: all the control of water is contained on panel A, the fans and draft on panel B, the fuel on panel C. All turbine controls and instruments for one turbine are contained on panels D, E and F, having hydrogen control on panel F, and supervisory on panel E, excepting generator excitation and synchronizing. The electrical duplex panels supplied by the General Electric Company are arranged in a straight line along the west side of, and symmetrically about east and west centerline of, the control room. Electrical switching for all four units will be controlled from these panels, together with auxiliary bus controls.

An L. & N. general plant panel, located at the center of the control room, provides for such plant facilities as air compressors, well-water pumps and wells, water softener, ash-sluicing water pumps, and station barometer, together with necessary alarms for some of these items.

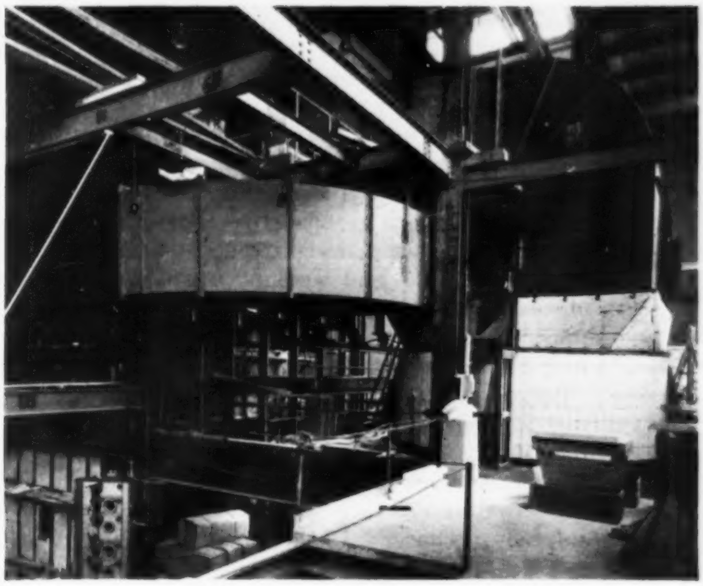
The control room is ventilated by a forced-air system which draws air from above the roof outside of building through filters and heater coils, with the fan discharging via a duct system through ceiling registers, and maintaining a positive pressure of air in control room at all times. The panels are of opalescent gray color with a gray tile base, the ceiling of plaster painted white, with carefully arranged flush lighting, walls of clear glazed tile and the concrete floors of green asphalt tile. All connections to panels enter through the floor and all panels are set on rubber mounting to prevent any vibration from affecting the instruments.

Coal and Ash Handling

Coal is all received via railroad hopper-bottom cars, switched in daily as required, generally from strip mines in the southwest part of the state. A 45-ton G. E. diesel locomotive, operating on the station end of cars at all times, pulls groups of four cars over to this track hopper. Two oil-fired car thaw-out pits will also be provided near the hopper. The 58-ft long hopper will handle two short cars or one long car and has a capacity somewhat in excess of two small cars. A Robbins car shakeout, hung from a trolley hoist in the coal-unloading building, vibrates each car so that the coal therein is unloaded within three minutes. The coal-unloading building also provides an office, a warm-up room, shower room, toilets and lockers for the operators, also a coal-sampling room and an

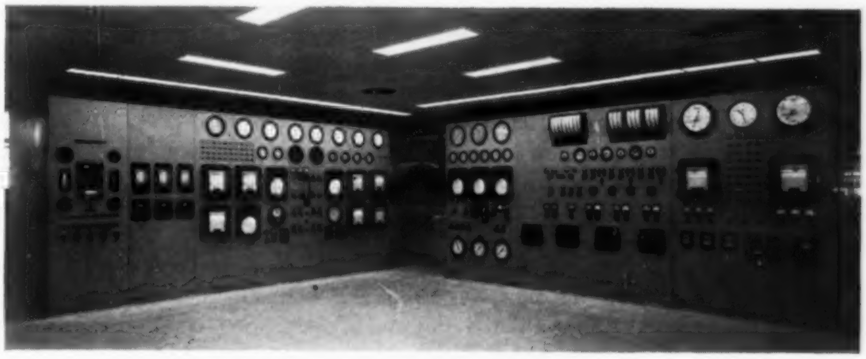


Main floor of boiler room showing coal feeders at right, coal pipes at center, hot-air ducts to the left and cold-air duct coming out of forced-draft fan room at extreme left



View at air preheater level

Control room showing boiler No. 1 control panel at right and turbine No. 1 panel at left



View of turbine room with first unit in place

electrical switchgear room for motor controls. All of the coal-handling system is controlled from a panel located in the office room and was furnished by the Link-Belt Company.

Reciprocating feeders under the track hopper feed onto a 48-in. reversing belt which discharges either to the 36-in. incline to the yard storage belt, or onto a 36-in. inclined belt feeding coal crushers in a separate crusher building. This latter belt has a Merrick weightometer which is the only means of obtaining coal weights, other than car weights, on the initial installation. The coal-storage pit provides for 150,000 tons of storage which will last the ultimate four-unit plant about 100 days of continuous operation. The coal is spread over the pit by a bulldozer and carryall, and reclaimed by a carryall driving over and dumping into the track hopper where a heavy iron grid is installed between railroad tracks to support the tires and allow coal to flow through to the hopper below.

The 36-in. belt discharging to the crusher is equipped with a magnetic pulley for removal of tramp iron and an inclined vibrating screen to sift out the fine coal pulled over with the iron. A 400-ton-per-hour American ring-type crusher discharges coal onto another 36-in. inclined belt of 400-ton-per-hour capacity which carries coal into the plant, where an automatic traveling tripper discharges it through rubber dust-sealing strips into the steel-plate gunite-lined bunker. The coal bunker will eventually be continuous the full length of the building for four units. The portion opposite each boiler provides a capacity of 960 tons. Each bunker has three 30-in. square gate outlets that feed into a trash bar screen grid compartment which in turn feeds into the coal feeders located on operating floor. Syntron vibrators are provided near each bunker outlet, on the screen grid compartment, and at the feeder outlet to insure positive flow of coal.

The three C-E Raymond bowl-type pulverizers are located on the basement floor at each unit and are equipped with a pyrites reject bin, which is provided with a hydraulic jet pump for quickly removing rejects and discharging them to a slag tank under the boiler.

The ash-handling system is of the hydraulic jet type supplied with water from duplicate full-capacity vertical turbine-type pumps which take water from a circulating water discharge duct. A United Conveyor 8-in. jetpulsion pump takes the ash and slag from the water-filled slag tank under the boiler and discharges through 8-in. Durite pipe to an outside ash-concentrating tank located west of the plant and north of the substation. From this point a 6-in. jetpulsion pump located under the tank sluices all ash through 1600 ft of 10-in. Durite pipe laid on the ground to the diked-in ash-fill areas located on the west side of the railroad tracks. The fly ash from boiler outlet hoppers and dust collectors is transported by vacuum to the inlet of a 4-in. pump which discharges through an air separator to the outside concentrating tank and then to fill.

Electrical Equipment

Generating at 13,800 volts, each unit feeds through underground ducts using four 1500 mcm Kerite cables per phase to its unit delta bus located in the substation. Three single-phase 14,583-kva Westinghouse transformers (17,000 kva fan-cooled rating) step up the voltage to 138,000 volts, feeding through oil circuit-breakers to the two (east and west) substation busses with all switching done on the 138-kv side. To each 138-kv substation bus is connected a circuit which transmits the power to the Indianapolis system via a steel transmission tower line 24.7 miles long.

The generator, main and auxiliary power transformers and 138-kv bus are included in the differential relay protection scheme. Transmission lines are protected by General Electric phase-comparison carrier current pilot relays with overcurrent, ground fault and directional distance back-up relays.

Auxiliary power for each unit is taken from the delta bus through a 3-phase 3750-kva (5000 kva fan-cooled rating) 13.8/2.4-kv Westinghouse outdoor transformer which feeds back into the plant, via underground cable and ducts, through two 1000-mcm cables per phase, to the unit's auxiliary bus in the switchgear room located at basement floor level between the turbine and boiler room.

A feeder from the 2400-volt general auxiliary bus supplies a 500-kva, 2400/480-volt unit substation located in coal-unloading building for coal-handling equipment motors. Metal-clad switchgear provides 2400-volt service to all motors 125 hp and larger. Air-cooled 2400/480-volt transformers and 480-volt metal-clad drawout-type gear provide service to the motors smaller than 125 hp. Motor protection consists of thermal overload relays actuating an alarm only for 115 per cent overload. The 2400-volt motor breakers are tripped by long-time-delay overload relays with instantaneous trip attachment, and 480-volt motor breakers by dual thermal-magnetic relays on excessive overloads or short circuit. Under-voltage time delay relays trip all auxiliary motors excepting the induced-draft fan and generator-exciter motors.

All switching is operated by 125 volt d c from the central control room. A battery room is located on a concrete floor above control room with a motor-generator set and d-c switchboard in a separate adjoining room for supplying requirements of Units No. 1 and No. 2. A second battery room and d-c switchboard will be installed adjacent thereto to serve Units No. 3 and No. 4.

Plant lighting is 3-phase, 4-wire with automatic throw-over of lighting panel emergency sections to d c on loss of normal a-c supply.

Plant communications consist of dial telephones with an automatic switchboard located in office building. Call bells at various points operate code calls, and it is possible to dial the call bell from any phone in the Indianapolis Power & Light Company's telephone system. A carrier current telephone provides direct communication between switchboard operator and the load dispatcher in Indianapolis. An Executone system with seven trumpets and answering stations provides direct and instantaneous communication between the control room operator and any auxiliary operator in the plant. This system is to be duplicated for each unit as it is installed.

Initial Operating Notations

Unit No. 1 was synchronized on February 23 carrying 5000 kw with the boiler fired with oil. On February 25 the mills were put into service, and a load of 20,000 kw was carried up to March 4 while the General Electric engineers were checking balance on unit. The unit was taken out of service for three days to make several minor changes in piping and to put hydrogen in the generator,

and on March 6 was again put on the line and gradually brought up to full load of 40,000 kw. Since that time two forced outages have occurred, one due to construction electricians actuating a relay which tripped out a breaker in the substation, the other due to a faulty relay operation at the Indianapolis end of the transmission line. During both these outages the unit maintained its speed carrying the plant auxiliary load, and the newly trained operators handled the equipment very satisfactorily, bringing the unit back on the line again within five minutes.

A completely new crew of operators was trained in advance to operate the station. Liberal use of instruction books provided advance information on the equipment installed and competent service engineers were provided for checking, starting up, and instructing the operators on all major equipment.

Equipment testing was organized during November 1948, and all equipment was always started and operated by the operating engineers to give them experience and insure good care of equipment.

PRINCIPAL EQUIPMENT—UNIT NO. 1, WHITE RIVER GENERATING STATION

Indianapolis Power & Light Company

Turbine-Generator

Turbine-generator .... *General Electric Co.*
40,000-kw Preferred Standard 850 psi, 900 F throttle steam, 1.5 in. Hg abs exhaust, five bleed points, 3600 rpm, 13,800 volts, 3-phase, 60-cycle, 150-kw separate exciter, hydrogen-cooled.

Condenser .... *Ingersoll-Rand Co.*
30,000 sq ft, two passes, divided water box.

Condenser tubing (arsenical admiralty $^7/_8'' \times 22'$) .... *Bridgeport Brass Co.*

Circulating pumps, 2 .... *Ingersoll-Rand Co.*
16,250 gpm, 30 ft tdh, vertical driven by 150-hp, 880-rpm motor.

Condensate pumps, 2 .... *Ingersoll-Rand Co.*
670 gpm, 300 ft tdh, vertical driven by 75-hp, 1765-rpm motor.

Two-stage steam-jet air ejector .... *Ingersoll-Rand Co.*

Priming ejector .... *Ingersoll-Rand Co.*

Oil purifier .... *Bowser, Inc.*

Steam Generating Equipment

Boiler, 1 .... *Combustion Engineering-Superheater, Inc.*
3 drums, 400,000 lb per hr, 875 psi and 900 F at superheater outlet, 6640 sq ft water-wall surface, 18,906 sq ft boiler surface, 23,200 cu ft furnace volume, 22,500 Btu per hr per cu ft heat release, slagging bottom discharging to water-quenching hopper.

Superheater .... *Combustion Engineering-Superheater, Inc.*
Two-stage interbank, 13,796 sq ft, controlled bypass.

Air preheater, 1 .... *Air Preheater Corp.*
Ljungstrom type, 69,700 sq ft

Pulverizers, 3 .... *Combustion Engineering-Superheater, Inc.*
Raymond bowl mill size 533A, 21,600 lb per hr, complete with exhausters and feeders.

Coal .... Indiana Bituminous
11,000 Btu as fired; sulfur 4.0%; moisture 13.0%; vol matter 35.2%; fixed carbon 40.0%; ash 11.8%; softening temp. of ash 1950 F; grindability 55 Hardgrove.

Forced draft fan, 1 .... *American Blower Corp.*
116,000 cfm against 12.8 in. H_2O, 2 motor drive, 350-hp, 1170-rpm and 75-hp, 685 rpm.

Induced-draft fan, 1 .... *American Blower Corp.*
206,000 cfm against 13.6 in. H_2O, 2 motor drive, 700-hp, 705 rpm and 125 hp, 388 rpm—totally enclosed motors with internal heaters.

Blowoff valves .... *Yarnall-Waring Co.*

Safety valves .... *Manning, Maxwell & Moore, Inc.*

Steam soot blowers .... *Diamond Power Specialty Corp.*

Water columns .... *Diamond Power Specialty Corp.*

Coal-handling equipment .... *Link-Belt Co.*

Ash-handling equipment .... *United Conveyor Corp.*

Mechanical dust collector .... *Western Precipitation Corp.*

Ducts and breechings .... *Connery Construction Co.*

Radial-brick stack (14 ft id × 250 ft high) .... *J. M. Cutshall & Sons*

Feedwater Equipment

Boiler feed pumps, 3 .... *Ingersoll-Rand Co.*
Two, 433 gpm, 2680 ft head, 3570 rpm, each driven by 450-hp motor. One, 433 gpm, 2680 ft head, 3570 rpm, dual driven by 450-hp motor and *Terry* steam turbine.

Low pressure heater, 18th stage .... *Westinghouse Electric Corp.*
1630 sq ft, internal drain cooler, 125 psig water, full vacuum or 50 psig steam.

Low-pressure heater, 15th stage .... *Westinghouse Electric Corp.*
1320 sq ft, internal drain cooler, 125 psig water, full vacuum or 50 psig steam.

Deaerator, 12th stage .... *Cochrane Corp.*
Direct-contact tray type, 400,000 lb per hr, 50 psig.

Evaporator, 7th stage .... *Westinghouse Electric Corp.*
12,000 lb per hr, 175 psig water, 50 psig steam.

High-pressure heater, 7th stage .... *Foster Wheeler Corp.*
1950 sq ft, internal drain cooler and desuperheat zone, 1300 psig water, 175 psig steam.

High-pressure heater, 4th stage .... *Foster Wheeler Corp.*
1486 sq ft, desuperheat zone, 1300 psig water, 350 psig steam.

Evaporator feed pumps, 2 .... *Ingersoll Rand Co.*

Heater drainers .... *Fisher Governor Co.*; *Stets Co.*

Piping, Valves and Insulation

Piping fabricator .... *Midwest Piping & Supply Co.*

Piping erector .... *Freyn Brothers, Inc.*

Insulation contractor .... *Philip Carey Mfg. Co.*

Cast-steel valves .... *Walworth Co.*

Forged-steel valves .... *Edward Valves, Inc.*; *Manning, Maxwell & Moore, Inc.*

Bronze valves .... *Wm. Powell Co.*

Cast-iron valves .... *Wm. Powell Co.*; *Crane Co.*

Miscellaneous valves .... *Ruggles Klingemann Mfg. Co.*; *Fisher Governor Co.*; *Henry Pratt Co.*; *Manning, Maxwell & Moore, Inc.*; *Atwood & Morrill Co.*; *The Swartwout Co.*; *A. W. Cash Co.*; *Crane Co.*

Traps and strainers .... *Armstrong Machine Works*; *Henry Vogt Machine Co., Inc.*; *McAlear Mfg. Co.*; *Elliott Co.*

Piping specialties .... *Armco Drainage & Metal Products, Inc.*; *United States Rubber Co.*; *E. B. Badger & Sons Co.*; *Liquidometer Corp.*; *Sarco Co., Inc.*

Instruments

Automatic combustion control .... *Leeds & Northrup Co.*

Feedwater control .... *Bailey Meter Co.*

Automatic boiler feed recirculation .... *Bailey Meter Co.*

Condenser hotwell control .... *Bailey Meter Co.*

Superheater bypass control .... *Leeds & Northrup Co.*

Temperature recorders .... *Leeds & Northrup Co.*

Conductivity recorders .... *Leeds & Northrup Co.*

Liquid-level recorders and indicators .... *Bailey Meter Co.*; *The Foxboro Co.*; *Bristol Co.*

Flowmeters .... *Bailey Meter Co*; *Cochrane Corp.*

Pressure gages .... *Manning, Maxwell & Moore, Inc.*

Thermometers .... *Palmer Thermometers, Inc.*

Instrument control panels .... *Leeds & Northrup Co.*

Electrical control board .... *General Electric Co.*

Electrical Equipment

Main transformers, 3 .... *Westinghouse Electric Corp.*
Single-phase, 14,583-kva self-cooled, 17,000 kva automatic fan-cooled, 13,200-v delta/138,000-v wye.

Generator auxiliary transformer, 1 .... *Westinghouse Electric Corp.*
Three-phase, 3750-kva self-cooled, 5000-kva fan-cooled, 13,200-v delta/2400-v delta.

General auxiliary transformer, 1 .... *General Electric Co.*
Three-phase, 3750-kva self-cooled, 5000-kva fan-cooled, 132,000-v wye/2400-v delta.

138-kv oil circuit-breakers, 3 .... *Westinghouse Electric Corp.*

Disconnecting switches .... *Railway Industrial & Engineering Co.*

Substation structures .... *American Bridge Co.*

2400-volt metalclad switchgear .... *General Electric Co.*

480-volt unit-type substations .... *Westinghouse Electric Corp.*

Motors .... *Westinghouse Electric Corp.*; *General Electric Co.*

Motor starters .... *Cutler-Hammer Co.*

15-kv cable .... *The Kerite Co.*

5-kv cable .... *General Electric Co.*

600-volt cable .... *Anaconda Wire & Cable Co.*

Generator neutral equipment .... *General Electric Co.*; *Westinghouse Electric Corp.*

Battery and charging equipment .... *General Electric Co.*

200 kw diesel engine-generator .... *General Motors Corp.*

Miscellaneous Equipment

Intake water screens, 2 .... *Link-Belt Co.*

Turbine room crane, 25 ton .... *Harnischfeger Corp.*

Hand hoists .... *American Chain & Cable Co.*; *Chisholm-Moore Hoist Corp.*

Tanks .... *Emerson-Scheuring Tank Mfg. Co.*

Air compressors .... *Worthington Pump & Machinery Corp.*

Water softener equipment .... *Cochrane Corp.*

Chlorination equipment .... *Wallace & Tiernan Products Co.*

Wells and pumps .... *Layne Northern Co.*

Car thaw-out equipment .... *Hauck Manufacturing Co.*

Elevator .... *Otis Elevator Co.*

CO_2 protection—oil room .... *Walter Kidde & Co.*

Pumps .... *Aurora Pump Co.*; *American Marsh Pumps, Inc.*; *Viking Pump Co.*; *Proportioneers, Inc.*; *Ingersoll-Rand Co.*

Construction

Supervision .... *Gibbs & Hill, Inc.*

Surveys .... *M. G. "Ole" Johnson & Associate.*

Trackwork .... *Central Engineering & Construction Co.*

Excavation and substructure .... *Smith & Johnson*

Structural steel fabricators .... *Jos. T. Ryerson & Son*; *Pan American Bridge Co.*

Structural steel erector .... *Pentecost Steel Erection Co.*

Masonry work .... *F. A. Wilhelm*

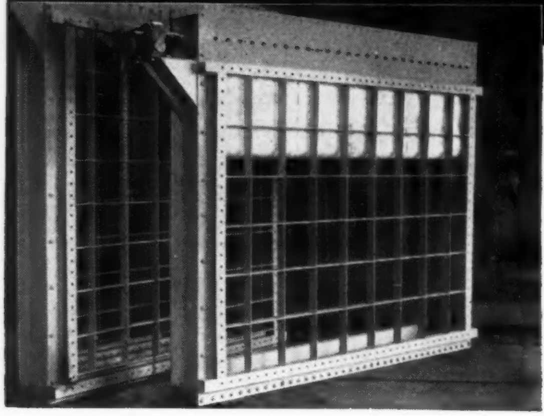
Mechanical installation .... *Gibbs & Hill, Inc.*

Electrical installation .... *Watson-Flagg Engineering Co.*

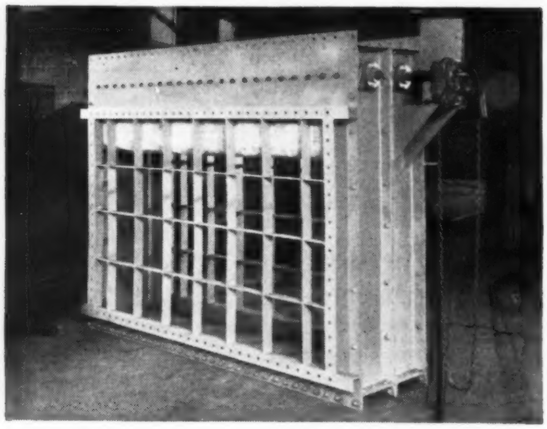
Painting .... *George L. Condos*

Design engineers .... *Gibbs & Hill, Inc.*

for single direction flow . . . or reverse flow control . . .



SVH Type Heacon Damper regulates flow in one direction.



DVHR Type Heacon Damper regulates flow in either direction. Note double grill against which two curtains ride.

HEACON DAMPERS

handle both!

Illustrated on this page are two types of the most widely used dampers. The SVH (single curtain—Vertical damper—Horizontal duct) and the DVHR (double curtain—Vertical damper—Horizontal duct—Reversing flow).

These types answer most damper requirements and, although tailor made to the application, they are considered the basic Heacon Damper design.

The Heacon Damper is unique in design. Sealing off and control of gases is accomplished by means of a flexible curtain of steel, asbestos, rubber or canvas, depending on application. This curtain operates vertically and is held against the grille and seals by the flow. As the curtain is rolled up, opening the damper, it peels from the grill. This action relieves the operating spindle of all torque, and permits the use of a constant, moderate power for operation.

Flow curve of the Heacon Damper may be modified to almost a straight line by means of V-porting. This is particularly important when the damper is to be used as a control mechanism. Some advantages of the Heacon Damper are: Better Regulation, Increased Capacity, Appreciable Reduction in Maintenance, Lower Banking Losses and Constant Power Requirements for Operation.

Let our engineers assist in solving your damper problems. A call or letter will bring you our Heacon Bulletin No. 10.

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The Eleventh Midwest Power Conference

JUDGED by the attendance at all sessions, the excellence of the program and the general high quality of the papers presented, the Midwest Power Conference at Chicago, April 18–20, established this annual event as foremost among meetings devoted to the interests of power engineers. Space here does not permit a review of all the papers; hence those dealing with electrical subjects, heating and ventilating, and diesel power are omitted, as are also several excellent addresses on general topics. Among the sessions pertinent to steam power were several on power supply, feedwater conditioning, steam contamination, modern steam generators, turbine design, central stations, small power plant problems, and atomic power; these are abstracted briefly.

Power Supply and Requirements

After citing a number of curtailments of power supply in various sections of the country in 1947 and 1948, due to insufficient reserves to cope with fast growing demand, **E. R. de Luccia** of the Federal Power Commission estimated that by 1960 national power consumption for the year will reach 600 billion kilowatt-hours and the capacity demand 134 million kilowatts, including necessary reserves. These figures include both public utilities and private industrial plants generating their own power.

Of these totals, utility output would be 525 billion kilowatt-hours, an increase of 85 per cent over 1948, and privately generated power 75 billion kilowatt-hours, an increase of approximately 40 per cent over 1948. To provide this, the respective installed capacities, including adequate reserves, would need be 115 million kilowatts and 19 million kilowatts.

The electric utilities are now installing new generating capacity at an unprecedented rate, with annual additions expected to average 6 million kilowatts during 1949–1951. If capacity continues to be installed at this rate, the nation's utility power supply by 1952–1953 may reach a point where more nearly adequate reserves will be availabe in most regions, although some shortage of power in the Northwest may be expected until 1954.

Mr. de Luccia considered reserves up to at least 15 per cent as essential.

Power Supply and National Security

Quoting from the published report of Colonel Keller concerning the difficulties encountered in providing adequate power supply during World War I, when the situation was administered by the U. S. Army Corps of Engineers, **Edward Falck**[1] cited in contrast the successful experience during World War II when mobilization of power supply, control of new construction, and allocations of service, were handled by a civilian group of power men constituting the Office of War Utilities, as a part of the War Production Board. These were

[1] Chief consultant on power and utilities, National Security Resources Board, Washington, D. C.

selected individuals from utilities, equipment manufacturers and federal power agencies who were able to accomplish results through intimate knowledge of the situation and through securing cooperation of all concerned.

Many of these men have formed the nucleus of an advisory group which has since been called upon from time to time, first during the coal strike crisis of 1946, later to assist in developing certain power phases of the Marshall Plan, and also to assist the National Security Resources Board.

Mr. Falck reviewed the organization and the planning functions of this Board with particular reference to its Power and Utilities Division, which is akin to the previous Office of War Utilities. However, its peacetime staff is very small with the division work being carried on primarily through industry advisory and task groups which to date have completed two comprehensive power surveys, as well as some special regional reports. A revised study of capacity and requirements of electric power systems is expected to be completed during the present year.

Power Supply to Chicago

At the joint luncheon with the A.I.E.E. on Tuesday, **T. G. Le Clair** spoke on "Power Supply for a Large Metropolitan Area," taking that of Chicago and vicinity as typical. This is provided by the Commonwealth Edison Company and three associated companies supplying the city and surrounding territory through an interconnected system and serving approximately 4 per cent of the population of the United States. It represents an investment of $4 for each dollar of annual revenue and $50,000 per employee. For this reason careful estimates are necessary in planning for the future. This is done on an inter-company basis through committees on estimates, on loaded capacity and on power supply, but each company does its own distribution planning. In the post-war period, through December 1948, 188 million dollars were thus spent in providing new facilities, and a ten-year growth of 60 per cent is anticipated.

Mr. Le Clair showed the location of present and new capacity, including the new Ridgeland Generating Station located on the Sanitary Ship Canal, which will initially contain two 150,000-kw units and have 600,000-kw ultimate capacity. The steam conditions are 1800 psi, 1050 F with two 750,000-lb per hr boilers serving each turbine. Complete centralized control will be provided and coal will be supplied by barge, from a central coal-loading plant at Havana on the Illinois River.

Carryover Identification

P. B. Place, of Combustion Engineering-Superheater, Inc., presented a paper on "Carryover Identification" in which, excluding silica carryover by vaporization, he grouped the sources under four general classifications, namely, (1) priming, (2) foamover, (3) spray, mist and fog, and (4) leakage past steam purifying equipment. Each of these have characteristic reactions to changes in operating variables. Hence by determining the effect of changes in operating conditions on the carryover, the type and source can usually be recognized and corrective steps taken. However, in making such tests it is important that only one operating variable function at a time.

Priming is essentially the result of too high a water level or of unshielded tubes that may spout into the steam outlet, whereas foamover is the development of various degrees of moisture in the steam due to carryover of foam from the drum. When foaming occurs with increase in concentration, priming will turn into a bad foamover. Thus, sudden and excessive carryover that is not stopped by a radical reduction in concentration, that becomes worse with increase in rating and is sensitive to water level changes, is likely to be due to priming.

Leakage carryover is seldom excessive, but will slowly increase with increase in rating. It is not likely to be sensitive to changes in water level or boiler water concentration, and is usually indicated by presistent local failure of superheater tubes.

A true spray or mist carryover is due to insufficient filtering out of residual moisture in the steam, or to breakdown in capacity of the steam drying equipment. It is seldom excessive, in the sense that priming and foamover are excessive, and is generally independent of water level and concentration variations. Spray carryover is the source of impurity in commercially dry steam.

Carryover Diagnosis

Pointing out that sampling is the primary requisite for any carryover study, **J. A. Holmes** of the National Aluminate Corporation noted the reliance that must be placed upon a very small sampling tube which must be properly located and correctly used. He suggested that close attention be paid to the requirements set forth in the A.S.M.E. Power Test Codes in order to insure correct sampling.

Calorimeter tests are of little value for determining steam quality because the calorimeter is not sufficiently sensitive at elevated pressures. Gravimetric methods of steam analysis are only used when an exact analysis is desired of specific solids carried over. Far more desirable is the electrical conductivity measurement of condensed steam, by which a continuous record may be had over a period of time. With this method it is important that the steam be degasified in order to insure reliable results.

Complications in diagnosis of carryover arise when more than one type takes place at a given time. Foaming and priming are probably found together most frequently, and under this condition the conductivity chart discloses sudden sharp peaks or a slow rise. The duration of priming in a potential foaming water is longer than in a non-foaming type boiler water.

Silica carryover is a special type of steam contamination usually confined to high-pressure boilers and requires special study for its prevention. Conductivity equipment cannot be relied upon to record volatile silica as such, thus necessitating an analytical procedure involving a colorimetric test for silica. Soluble silica carryover as sodium silicate can be reduced by the use of antifoams.

Too much emphasis cannot be placed upon careful and adequate testing of carryover. If these tests enable

the determination of its cause, corrective measures can be adopted and carryover from the same cause will rarely reoccur.

Steam Contamination Experience

Steam contaminants, according to **W. L. Webb** of the American Gas & Electric Service Corp., give the power plant operator little concern until they leave their mark by being deposited at some point in the cycle. In superheaters these deposits may cause tubes to overheat and fail, while in feedwater heaters and surface condensers, heat transfer characteristics may be impaired. Turbine performance may also be adversely affected.

In several plants turbine deposits became less troublesome when SiO_2 concentration in 1300-psi boilers was reduced to the range of 2 to 5 ppm. In another station, by lowering steam temperature gradually from 950 F to 620 F at subnormal loads and then restoring it to normal, deposits causing high-pressure differentials in turbine elements have disappeared.

Deposits on the shell sides of feedwater heaters and surface condensers contain large proportions of iron oxide. There is also some oil, which is subjected to partial cracking at superheat temperatures and deposits as a thin, highly insoluble film that cannot readily be removed by conventional acid or alkali cleaning solvents.

Feedwater heater deposits reduce heat-transfer rates, resulting in a decrease of the quantity of bled steam condensed in the heater and thereby imposing a greater burden on the next higher pressure heater in the cycle. The latter results in a reduction in the kilowatts produced for the same throttle flow and ultimately in an increased plant heat rate.

No means of preventing feedwater heater deposits have been found, aside from minimizing condenser leakage. That this problem and the related one of turbine deposits is serious is shown by a recent survey in which more than 750,000 kw are affected.

In many instances, deposit removal is required more frequently than can be handled during scheduled overhaul periods, and capabilities and efficiencies of individual units have been reduced as much as 12 per cent and $8^1/_2$ per cent, respectively.

Water Treatment for High-Pressure Plant

A paper by **Louis Wirth, Jr.,** of the Dow Chemical Company, described water treatment procedures at the Midland, Michigan, plant of that company. Approximately 40 million pounds of steam is generated per day at 400 psig and 1250 psig. In a typical 24-hr period makeup demands may run to 27.75 million pounds, or 2310 gpm, and to meet this need demineralization capacity of 3000 gpm is now under construction.

Because of the nature of the chemical processes, some condensate is contaminated. To protect the boilers a system of condensate metering and selection for purity is maintained by each major steam user, and under certain conditions contaminated water may be diverted out of the system. Special vigilance is required to detect and minimize organic substances having little or no conductivity.

Internal conditions of the 1250-psig boilers are controlled by feedwater attendants, who attempt to keep total dissolved solvents near 350 ppm with a phosphate content ranging from 30 to 50 ppm. The control of all boiler water concentrations is handled directly in the boiler room with conspicuously displayed boiler water conductivity recorders as the operating guide. The attendant is responsible for maintaining the concentrations as prescribed for the individual boilers by the control laboratory.

The operation of a feedwater system of the size described requires the use of a central power laboratory where results are checked and data are compiled. In the laboratory it is found that a better quality of work can be done by personnel having a limited knowledge of the subject. On the other hand, operators of feedwater conditioning equipment require specialized training, and to that end a 48-week course is offered, successful completion of which is essential to further advancement in boiler plant operation.

Feedwater Conditioning at Canadian Steel Plant

Problems of feedwater conditioning in the new central boiler station of The Steel Company of Canada, Ltd., at Hamilton, Ontario, were discussed by **A. C. Elliott.** The new station consists of four steam generating units, each with a capacity of 125,000 lb per hr at 460 psig and 750 F. One of these burns coke breeze, while the other three use blast furnace gas as a primary fuel.

Normal mill water supply is from Burlington Bay, which is the western tip of Lake Ontario, and is contaminated by sewage, industrial wastes, acids, alkalies, oils, flue dust and surface silts. During the navigation season, the turbidity and suspended solids concentration of the water are accentuated.

A two-stage, hot lime-soda-phosphate system was chosen for water conditioning. One advantage of this system is that turbidity and hardness may be removed in one apparatus without pretreatment. Also, considerable storage material can be provided without adding much to initial cost. Lime-soda-phosphate systems favor the heating of feedwater and can therefore utilize low-pressure exhaust steam. Deaeration can be carried out with the same equipment.

The speaker concluded by discussing operating experiences and minor changes that were made in the water treating system to improve performance.

Refinery Boiler Feedwater Treatment

A detailed description of feedwater treatment for 1500-psig boilers at the Whiting Refinery of the Standard Oil Company (Indiana) was given by **Glenn Hull.** The refinery uses 100 per cent makeup, the water being obtained from Lake Michigan.

In the treatment process the water enters the raw water storage tanks after having been passed through refinery waste heat exchangers. It is carried through vent condensers and is discharged into lime-soda softeners and then into phosphate softeners. Next it flows through anthracite filters, from which the treated water pumps transfer it to the deaerating heaters and through the boiler feed pumps into the boilers.

The lime-soda softeners and the phosphate softeners operate in pairs. They are equipped with variable speed agitators, and their bottoms are designed with an inclined angle to facilitate sludge removal. The softeners, which operate at 10 psig, have a rated capacity per unit of 80,000 gallons per hour. The treating house is adjacent to the softeners and contains chemical mixing tanks, chemical feed pumps, sludge recirculation clear water pumps, control panel and related equipment.

A laboratory is maintained to analyze samples at regular intervals and to calibrate testing and recording equipment. The chemical engineer in charge of the laboratory makes a daily comparison of the laboratory findings and the operating tests and operating results of the treating equipment. Any corrective steps that are indicated are put into effect through supervisory personnel of the operating department.

Hot lime-soda-phosphate treating plants are frequently used to prepare water for boiler feed purposes for boilers operating at relatively low pressures. It is believed that this is the first time that water treated in this manner has been used to feed 1500-psig boilers with 100 per cent makeup. Operating results from May 1948 to date have been satisfactory.

Treatment of Cooling Water

Many industries use large quantities of cooling water. Where the supply is unlimited and conservation not a factor, the once-through system is generally employed; but with limited supply resort is had to a recirculation system employing cooling towers, spray ponds, evaporative condensers, etc. In either case the heat-exchange equipment may be subject to scale formation, corrosion, or slime accumulation. The problem of treatment in such cases was covered in a paper by **L. Drew Betz** and **John J. Maguire,** of W. H. & L. D. Betz, Philadelphia water conditioning consultants.

Calcium carbonate is usually the chief ingredient of scale formed in a once-through cooling system, it being more insoluble than calcium silicate or calcium sulfate. Because of the large volumes of water to be handled in such a system, external softening is not feasible, the most common method employed to inhibit scale formation being the use of various surface-active agents to prevent crystal growth. The materials most commonly used for this purpose are polyphosphates, tannins, lignins, starches, and combinations of these.

The principal factor causing corrosion and pitting in a once-through system is dissolved oxygen which attacks ferrous metals. The action may be enhanced by low pH due to CO_2 and SO_2; also by increase in temperature. Copper and copper-bearing alloys such as frequently used in heat-exchangers and condensers afford increased protection against corrosion. Its prevention is accomplished either by forming a calcium carbonate scale on the metal surface to act as a protective barrier by use of surface-active inhibitors or by elimination of the oxygen from the water.

Fouling of heat-exchangers by slime growths may present a serious operating problem, particularly in a recirculating system. Intermittent chlorine treatment is generally employed to control such growths in once-through systems.

With an open recirculating system where the water becomes concentrated by evaporation, the problem of scale formation is increasingly troublesome; but the basic treatment is the same as that employed in a once-through system, although higher treatment concentrations are maintained. The surface-active materials employed are usually a blend of several organic and inorganic agents.

The problem of corrosion in an open recirculating system, like that of scale formation, is also intensified in comparison with once-through operation. The most satisfactory method of avoiding corrosion in such cases is to employ inhibitors that render the metal of the system passive to oxygen attack. Such agents are chromates, surface-active phosphates, nitrites, amines and various nitrogenous organic materials.

While chlorination is a standard treatment for slime control for once-through systems, in recirculating systems the volatility of the chlorine is a disadvantage. However, it is often employed, although copper sulfate is most widely used.

Cooling Tower Water Treatment Problems

Experiences in treating water for cooling tower use at the Lockport, Illinois, plant of The Texas Company were described by **E. C. Hosbach,** power engineer. Makeup water is obtained from the Chicago Drainage Canal, and in the past treatment had been by means of chlorination. However, heavy incrustation took place, sometimes causing loss of metal to the point of pipe failure. Studies indicated that sulfate reducing bacteria were a major cause of slime deposits where pitting and corrosion were found.

To correct this condition a program of treatment was adopted which used a proprietary material, "polysulfate" coupled with an inorganic synergist, together with sulfuric acid for pH control. Steps were also taken to avoid loss of water and to recirculate it as much as possible, thereby reducing chemical consumption to about one-eighth of that required when higher water wastage was involved.

Two types of treatment control are maintained. Total PO_4 is kept between 30 and 40 ppm, and pH is allowed to vary from 6.0 to 6.5. The use of chlorine has not been entirely eliminated, but it has been materially reduced with equal or, in some instances, improved slime control.

Justification for the new chemical treatment is found in the pronounced reduction in maintenance and cleaning time of cooling equipment. The rate of deterioration of metal surfaces has been reduced better than 90 per cent, thus deferring major expenditures for equipment replacement. Indirect savings have also been realized in pumping costs and in improved heat transfer rates.

Silica Carryover

In a paper discussing silica carryover and turbine blade deposits, **Prof. F. G. Straub,** of the University of Illinois, pointed out that at normal boiler concentrations

salts do not become appreciably soluble in saturated steam at pressures below 2000 psi. However, below 2000 psi salts concentrated in the superheater may become soluble in the superheated steam.

Some salts present in the boiler water tend to leave the water as vapor or gas; even at low pressures. Thus CO_2 entering a boiler will go over with the steam, forming carbonic acid and sodium hydroxide and lowering the pH. Similarly, sodium silicate will hydrolyze and form silicic acid and sodium hydroxide, but does not affect the pH. The former tends to vaporize and leave the boiler along with the steam. This seldom occurs below 600 psi, but at 1500 psi the silica in the steam will be about one per cent of that in the boiler water.

As the pressure and temperature decrease in the passage of steam through the turbine, a point is reached at which silicic acid crystallizes and deposits on the low-pressure turbine blades. It is not soluble in water, and the best remedy is to remove the silica at its source.

Removal of Silica From Feedwater

Three methods for removing silica from boiler feedwater were outlined and analyzed by **J. D. Yoder** of the Permutit Company. Advantages and disadvantages of each process were cited, and examples of application in power plant use were presented.

The ferric hydroxide absorption process is more effective in removing silica at the low temperatures commonly used for cold process softening. This method was first employed by the Gulf States Utilities at Baton Rouge, Louisiana, in the treatment of Mississippi River water for makeup to 900-psi boilers. Ferric hydroxide is produced by feeding ferric sulfate to the water and precipitating it in the alkaline pH region. This process has the advantage that it also serves as a coagulant and color remover; it has the disadvantage that it increases the total solids and does not reduce the silica to as low a figure as otherwise obtainable.

A second process is by means of magnesium hydroxide which is more effective in removing silica in hot water than in cold water. To reach equilibrium a relatively long contact time is required in removing silica by this method. Recirculation of sludge increases the contact time and improves the efficiency of silica removal. In the process, water is treated with soda ash and dolomitic lime in a sludge blanket softener. Silica content can be reduced to a lower value by this method than by ferric hydroxide, but not so low as by demineralization. Chemical cost is less than for either of the other processes.

Demineralization removes silica by first passing water through a hydrogen zeolite softener where practically all magnesium, calcium and sodium cations are removed. Then the carbonates, chlorides, sulfates and silica are changed to their respective acids and are removed by degasification and demineralization.

The effectiveness of the process is dependent upon the complete removal of cations in the first step. Demineralization has the advantage of removing other solids in the water at the same time that it reduces silica content to a value lower than can be achieved by the other two processes. At the same time its treatment cost is the highest of the three methods.

Steam Formation by Motion Picture Studies

Some interesting mechanisms involved in the origin of bubbles, their rate of growth and coalescence or resistance to coalescence, the influence of the nature of the heating surface and the action of organic foam inhibitors were revealed in high-speed motion picture studies presented by **L. O. Gunderson** and **C. M. Bodach** of the Dearborn Chemical Company.

The experimental boiler employed for the studies is a Pyrex glass cell with parallel sides wherein is mounted between vertical bus bars a thin horizontal metal strip approximately $2^1/_2$ in. by $^1/_4$ in. A variable rheostat permits changing the current input to regulate the rate of heating. Equilibrium temperature is assured by slow boiling on a hot plate.

Foaming is one of the special problems of steam formation. Polyamides are effective foam inhibitors and also drive out foreign foam-stabilizing material accumulated in surface films or steam bubble interfaces. Because of the latter property residual moisture in the steam is rendered less harmful.

High-speed motion picture observations have verified that roughened surfaces produce an increase in the number of bubble nuclei, whereas smooth heating surfaces produce fewer and larger bubbles. Adsorbed air may be responsible for the formation of bubble nuclei in steam generation, nonwettable spots on heating surfaces being particularly susceptible to the adsorption of oxygen. By adding a wetting agent to the water, this condition may be overcome.

The motion picture studies were made by utilizing a Fastax 16-mm high-speed motion picture camera capable of taking pictures at the rate of 150 to 5000 frames per second. At its maximum speed the exposure time for each frame is approximately $^1/_{25,000}$ second and provides a time magnification of approximately 300 times that of normal vision. The camera has no shutter. A revolving four-sided prism is synchronized with the film passed continuously over a revolving sprocket drum, taking four pictures for each revolution of the prism and exposing the 100 ft of film at maximum speed in less than one second. The exact timing is recorded on the edge of the film by a beam of light from an argon pilot lamp recording 120 dashes per second.

Evolution in Boiler Design

As typical of advancement in central station boiler practice over the last 20 to 25 yr, **E. M. Powell** of Combustion Engineering-Superheater, Inc., selected the designs of six successive units installed in the plants of one medium-size utility company during this period, all of which are pulverized coal fired and, with the exception of the most recent one now under construction, are all in service.

Unit capacities started with 120,000 lb per hr and stepped up to 250,000, 300,000, 400,000, 400,000 and 430,000 lb. Steam pressures ranged from 384 psi to 660, 660, 680, 1300 and 1400 psi, with corresponding steam temperatures of 680 F, 755 F, 755 F, 835 F, 955 F and 1000 F. The most recent unit, now under construction, employs gas reheat to the initial tempera-

ture, although steam reheat was used in some of the earlier installations.

The first of these units had refractory walls protected by a minimum amount of water cooling in the most active zone; the next (1935) had complete cooling of the lower walls and the subsequent units employed water cooling of the entire furnace. Vertical firing was employed on the first unit; the next three had horizontal turbulent burners; and the last two, tangential corner firing with automatically controlled tilting burners.

Steam Generator Developments

Under title "Recent Developments in Steam Generation," **Frank X. Gilg** of Babcock & Wilcox discussed high steam pressures and temperatures, steam temperature control, reheat, cyclone furnaces and pressure furnaces operating without induced-draft fans.

With reference to the first mentioned item, Mr. Gilg was of the opinion that there is not much use of going higher than 2500 psi, at which pressure natural circulation boilers are now in service; but that the possibility of further improvement in station heat rates lies in the direction of higher steam temperatures. These are at present limited to about 1100 F by the commercially available alloys. However, a research program is under way on higher austenitic alloys for temperatures up to 1600 F.

Methods mentioned and discussed for controlling steam temperature included an attemperator in the lower drum, bypass dampers, high-pressure water sprays in pipe between two sections of superheaters, recirculation of gas from economizer outlet into furnace at low loads, adjustment of the combustion zone, and combination convection and radiant superheaters.

The effect of reheating to the initial steam temperature is approximately the same as raising the initial temperature 150 to 200 deg F; thus reheat is one way of improving cycle efficiency by overcoming the temporary limit in steam temperature imposed by available alloy materials.

Steam generating units for the Sporn and the Tanners Creek Stations of American Gas & Electric Corporation were described. These are designed for 930,000 lb per hr at 2080 psi, 1050 F initial temperature and 1000 F reheat temperature.

Test results with various coals burned in the cyclone furnace were cited. Some of these, in which the slag flowed freely, had relatively high ash-fusing temperatures up to 2600 F.

The statement was also made that several central station units are now being built to operate without induced-draft fans. In these cases the furnaces operate under pressure.

Industrial Power Plant Design

Citing the importance of better power plant design as a means of reducing costs, **Parker A. Moe,** Milwaukee consulting engineer, emphasized the need for adapting such plants to meet the requirements of specific industries. Engineering studies to this end should cover both the supply of power and steam and its economical production.

From the economic point of view, the speaker contended that any prime mover for generating power is adequate as long as it generates all power requirements and all exhaust steam is utilized. Under these conditions savings cannot be achieved by installing a more efficient prime mover.

A tabulation was presented to show the additional coal required to generate power at different steam conditions, as contrasted to the fuel required for supplying process steam without power generation. Also illustrated in tabular form were the economies that may be realized by using topping turbines.

Cautioning against selecting boilers of insufficient capacity, Mr. Moe urged that furnace design be such as to permit the burning of low grades of fuel with furnace exit gas temperatures below ash-fusion temperature. Heat-recovery equipment should be provided whenever the load factor warrants. The speaker noted that fuel costs in excess of $80,000 annually may justify economizers, while air heaters sometimes provide an economic return with an annual fuel cost in excess of $40,000.

While good design is essential for industrial power plants, sight should not be lost of the importance of qualified operating engineers. In particular, there should be someone capable of maintaining instruments and controls. Training of key operating personnel is an important consideration for industrial power plants.

Small Plant Maintenance

Stressing the importance of setting up maintenance schedules for every piece of equipment in small power plants, **Leland J. Mamer** of The Evanston Hospital Association cited the following advantages of such a program: reduction of maintenance costs; less time lost due to unnecessary breakdowns; increased life of equipment; and assurance of attaining high overall efficiency.

In setting up such a system, equipment should be listed along with its size, type and other pertinent information. Dates of repairs and periodic checks should be noted in order to establish schedules so that only one piece of equipment is out of service at a time.

It is important that each operating engineer be made responsible for the inspection and routine maintenance of certain equipment. In addition there should be an adequate supply of tools and repair parts necessary for maintenance. Instruction sheets and an operating manual for each piece of equipment should also be available. Finally, good housekeeping not only minimizes dust and dirt but tends to make operators have pride in their work and consequently do a better job.

Preventive maintenance programs require considerable effort on the part of the chief engineer of each plant. However, the results are worth the effort, as indicated by savings in material costs averaging about 30 per cent over a period of eleven years in the speaker's plant.

Fly Ash From the Small Plant

Responding to the question, "What can a small plant do about fly ash?" **Carl E. Miller** of Battelle Memorial Institute reviewed the usual fly-ash problem in such plants and offered suggestions for combating it. Citing

the rather wide variance in allowable dust loadings as prescribed in various municipal ordinances, which range in typical cases from 0.85 to 2.49 lb per 1000 lb of flue gas, he expressed the opinion that the lower values should be considered in view of the present trend toward rigid regulations.

Stokers in many small plants are inadequate to meet maximum steam demands without increasing burning rates to the point of excessive stack emission; but conservatively designed installations employing underfeed stokers of ample capacity ordinarily have no difficulty in meeting ordinance requirements without dust collectors. This also permits wider flexibility in choice of fuel. The difference in stoker cost will be much less than the cost of collector equipment.

Where the total fly-ash emission is low, but large-size particles are a nuisance in the immediate vicinity, it was the author's opinion that a simple dust trap operating on natural draft may prove adequate.

Where higher burning rates are to be maintained regularly, a simple low-draft-loss collector will ordinarily suffice. Such a unit may be operated on natural draft, or if natural draft is inadequate a steam jet or an induced-draft fan may be employed.

However, on spreader stokers and others operating at high ratings, a high-draft-loss collector and induced-draft fan are usually required. In such cases the higher initial and operating cost of the collector is partially offset by ability to use lower cost coal and attain increased efficiency through reinjection of the cinder into the furnace.

Discussion

Among the several discussors of Mr. Miller's paper there was some feeling that many city councils, in adopting smoke ordinances, appear to be attempting the impossible as concerns the small plant. On the other hand, one discussor cautioned that low-draft-loss collectors with around 50 per cent efficiency will not meet present ordinances. There was general agreement that it is difficult to determine gas loading in a small plant without elaborate test, and that installation of collectors will make for greater flexibility in coal selection.

Maintenance of Packaged Boilers

The packaged steam generator, as defined by **F. W. Hainer** of the Cleaver-Brooks Company, is a self-contained boiler-burner unit, in sizes ranging between 15 and 500 hp with pressure from 15 to 250 psig. Generally, this boiler is of fire-tube design employing three or four passes without refractory setting, thus accounting for its portability and ease of installation. Oil and gas are usually burned, separately or in combination.

Loads in the type of installations most often served by packaged boilers are irregular. By maintaining high efficiency at variable loads without major losses due to shutdown or banking, such units find widespread use in small industries requiring both process steam and heating.

Small plants are often reluctant to call upon consulting engineers for professional services. Consequently, manufacturers are requested to provide guidance for prospective purchasers. However, the best small boiler plants are those which have employed the services of competent engineers.

In too many cases the chief consideration in purchasing a boiler is selection on the basis of maximum load. Very often neglected are seasonal load variations, night shutdowns, week-end shutdowns, the variable effect of the combination of heating and process loads, condensate return problems, feedwater conditioning, and fuel handling considerations.

The packaged steam generator is an exactly rated unit, and its size is expressed in terms of maximum continuous output. A flat high efficiency for steam loads between 30 per cent and maximum rating was claimed for the packaged steam generator by the speaker. He also mentioned the merits of a 24-hour efficiency rating, thereby taking into account low efficiencies at light loads and the effects of banking and starting-up losses.

In concluding, Mr. Hainer warned against casual consideration of the industrial boiler plant as just another domestic heating installation. The owner must understand the responsibilities of operating a packaged unit in order to get its benefits.

Post-War Turbine Design

Discussing recent developments in the design of high-pressure, high-temperature steam turbines, **C. W. Elston,** of General Electric Company, listed among post-war developments the first application of 1050 F throttle temperature and the first 100,000-kw machine to operate at 3600 rpm. There is an optimum initial pressure beyond which economy decreases for a given capacity; hence maximum pressures have not increased since 1941, although higher pressures, in general, have been promoted for smaller capacities. The speaker was of the opinion that higher steam pressures than those at present in use would not be found attractive in the near future.

Post-war designs have aimed at permitting operation at maximum capacity for long periods and provision for quick disassembly for inspection. Gains in turbine heat rates up to $4^1/_2$ per cent, due to increased throttle temperature, have been attained, and a new design of unit has been brought out for employing reheat. This, in the tandem-compound type, is less than 3 in. longer than the non-reheat unit; a central high-pressure inlet eliminates undesirable temperature stresses, and austenitic steel is being employed for 1050 F casings. Low alloy ferritic steels are also being investigated for this temperature.

Power Station Losses

"Evaluation and Location of the Losses in a 60,000-Kw Power Station" was the title of a paper presented by **C. Birnie, Jr.,** and **E. F. Obert,** of the Northwestern Technological Institute. In current power plant practice output is measured in terms of energy supplied, and efficiency is thereby determined. However, there is no criterion for determining whether this efficiency is inherent in the design of the plant itself.

By basing power plant analyses upon available energy instead of energy transfer, it is possible to compare the

maximum possible work that could be produced by the plant with that actually obtained. Exact evaluations may be determined for the steam generating unit, heaters, pumps, turbine, condenser and pipe lines.

Under the proposed method available energy may be utilized as effectively in a low-pressure, low thermal efficiency plant as in a high-pressure station with high thermal efficiency. Thus the method provides a common denominator for judging effectiveness of power plant design, since the actual cycle is charged only with the maximum work that could be produced by a perfect cycle operating within the same steam conditions.

The authors applied their evaluation to what was termed a plant typical of central stations constructed in the immediate pre-war period. Their study showed that the blowdown system is not as inefficient as might be supposed, while desuperheating, because of throttling, causes a relatively large loss in available energy. More data from various stations are needed to help establish better design and operational practices.

Progress With the Coal-Fired Turbine Locomotive

"Some of the Problems Involved in the Coal-Burning Gas-Turbine Locomotive" was the title of a paper by **C. K. Steins,** mechanical engineer with the Pennsylvania Railroad. This was in the nature of a progress report on a project that has been under development for several years and which has been reported on periodically in engineering society papers. It involves the design and building of two such locomotives—one of 4200 hp by the American Locomotive Company, employing an Allis-Chalmers turbine; and the other of 3750 hp by The Baldwin Locomotive Works with an Elliott turbine. Both will employ the open, regenerative cycle and an overall efficiency of about 20 per cent is expected, compared with 26 per cent for diesel-electric drive and $5^1/_2$ to 6 per cent for the modern steam locomotive. However, the higher efficiency of the diesel locomotive is offset by the very much higher fuel cost at prevailing oil prices.

While a satisfactory solution to all the problems has not been attained, progress is being made toward this end, as indicated by the following summary.

Pulverization to not over 10 per cent plus 100 mesh, 70 per cent minus 200 mesh and a considerable portion down to around 325 mesh will be necessary. The original plan to follow preliminary grinding with fine pulverization against a target by a fast moving air stream through a nozzle, has been abandoned in favor of full mechanical pulverization, as some of the larger particles were found to bounce off the target and a uniform product was not attainable. Also, it was difficult to find sufficiently suitable target material, cast boron carbide having shown up best. It now appears that a maximum of 75 hp will be required for the desired pulverization.

A second problem involves conveying the pulverized coal to the combustor against a static head of 54 psig. For this purpose a rotating coal pump, or wheel, has been designed but the clearances must be so small that satisfactory seals are difficult.

Combustor development is being carried on at Battelle Memorial Institute, the Alco Products plant at Dunkirk, N. Y., and at the Kaiser steel plant, Fontana, Calif. This involves heat releases up to $1^1/_2$ million Btu per cu ft per hr which have at times caused warping, localized burnouts and difficulties in operating over the range from idling to full load. However, with a hot-wall combustor, efficiencies up to 98 per cent have been attained.

Finally, in the matter of cleaning the gas before it passes to the turbine, a 180-deg conical louver followed by a battery of centrifugal separators, has been found to remove about 95 per cent of the ash, the remaining 5 per cent being so fine as not to injure the turbine blading.

The speaker mentioned that the General Electric Company is now testing a 4500-hp single-unit, oil-burning, gas-turbine locomotive, and Westinghouse Electric Corporation will shortly have on the rails a similar 4500-hp locomotive—both operating on an open, non-regenerative cycle. Also, the Santa Fe Railroad has on order from Baldwin an oil-burning gas-turbine locomotive.

Present Status of Atomic Power

Comparing the operation of a steam boiler with that of a nuclear reactor, **Dr. Norman Hilberry** of the Argonne National Laboratory indicated similarities and differences in energy producing processes that take place. Control of a boiler is achieved by regulating the rate at which coal and oxygen are admitted as compared to steam output. On the other hand, control of a nuclear reactor is determined generally by the number of neutrons present and can be carried out by inserting a neutron absorber into the region in which the reaction is taking place.

An essential difference between the steam boiler and the nuclear reactor is the presence of radioactive substances in the latter, thus requiring substantial shielding protection. Furthermore, there are problems of disposing of waste products of nuclear fission which have no counterpart in a steam boiler plant. It is also theoretically possible with the fission process to form more fissionable material in a nuclear reactor than can be used.

Segregation of various types of fissionable material is an important consideration which makes it essentially impossible to separate the economic implications of a supply of fissionable materials from their military implications. The same stockpile which represents potential industrial power also represents military potential in terms of atomic bombs. The very concentrated form of nuclear energy also makes it attractive for such uses as ship propulsion, where fuel storage may be a critical problem and the ability to have a cruising range almost independent of fuel requirements would be of great advantage.

The availability of nuclear power depends to some extent upon technical questions, but the determining factor lies in purely political considerations. The American public has a responsibility, through Congress, to set up a long range program if the national interest is really to be protected.

In concluding, Dr. Hilberry discussed briefly the four types of reactors now under development by the Atomic Energy Commission.

Slagging-Bottom Furnaces Abroad

THE accompanying tabulation of boilers with slagging-bottom furnaces installed in Germany and Czechoslovakia since 1935 is translated from a paper by **K. Heinrich** before the German Association of Large Boiler Users and published in a pamphlet issued by that organization dealing with the operation of high-pressure boilers.

From this it appears that the first slagging-bottom boilers in Europe were built by the Bruenn-Königsfeld Machine Works in the period between 1924 and 1927, and consisted of ten units having steaming capacities ranging from 9000 to 110,000 lb per hr.

Between 1932 and 1935, a few such boilers were erected in sizes from 60,000 to 176,000 lb of steam per hour; but the commercial market in Europe for that type of unit was slow in developing, in contrast with its growing popularity in the United States where the trend was toward large-capacity, heavy-duty steam generating units for which slagging-bottom furnaces were well adapted when burning coals of low ash-fusion temperatures.

However, as indicated by the tabulation, a considerable number of such boilers were built in Germany and Czechoslovakia subsequent to 1941, and in the former country some 25 are listed as under erection or projected. Except for size, they appear to have followed practice in the United States where the two leading boiler manufacturers had evolved two different avenues of approach —one employing a single completely water-cooled furnace, tangentially fired; and the other a double-chamber furnace with U-flame firing and refractory supported on peg tubes in the primary chamber. Both types are reflected in the foreign designs.

A more recent construction in Germany, aimed at increasing the heat-absorbing surfaces in the furnace and lessening slag accumulations, consists of placing so-called platen walls of water-cooled lanes spaced every 2 to 3 ft across the upper part of the furnace. These walls lower the temperature of the gases leaving the furnace and before entering the convection heating surface of the boiler.

SLAGGING-BOTTOM BOILERS ERECTED AND PROJECTED IN GERMANY SINCE 1935

No.	Capacity, Lb/Hr	Pressure, Lb/Sq In.	Temp., F	Fuel, % Moisture	Ash	Vol.	Btu/Lb	Milling System	Mfr. Furnace Boiler	In Operation	Type Boiler	Furnace
2	176,500	510	815	8	10	14	12,600	Pneuko	Babcock & Wilcox	......	Sect. Hdr.	Front firing, single chamber
1	198,500	455	805	18	20	21	8,600	4 H-S	B & W-Borsig	1942	Radiant	U-flame firing, double chamber
2	154,000	410	795	15–20	....	....	8,600	3 H-S	Babcock & Wilcox	1942	1 Sect. Hdr. 1 Radiant	U-flame firing, double chamber
3	55,000	285	660	18	38	5	7,500	Tube Mill Storage	Babcock & Wilcox	1944	Radiant	Corner firing, single chamber
1	176,500	2000	930	8	10	16	12,300	3 KSG	Duerr Wolf	1943	Radiant	Corner firing, single chamber
1	119,000	1775	930	54	7	....	4,300	2 Kraemer	VKW	1945	Schmidt	Front firing, double chamber
2	275,000	1630	950	1.3	15.6	18.5	12,300	3 H-S	1-VKW 1-Duerr	In erection	Benson	Side firing, corner firing, double chamber
12	275,000	1360	930	15	30	26	8,100–9,900	H-S	Babcock & Wilcox Steinmuller Duerr Walther	In erection	Radiant	U-flame firing, double chamber
4	275,000	1140	930	15	30	13	10,800	3 H-S	Babcock & Wilcox	Proj.	Radiant	U-flame firing, double chamber
1	275,000	1140	930	20	20	27	7,200–8,100	Tube Mills Storage	Borsig	Proj.	Radiant	U-flame firing, double chamber
6	275,000	950	930	14	30	....	....	Tube Mills Storage	Bruenner Skoda	Proj.	Radiant	U-flame firing, double chamber

It will be noted from the tabulation that, while many of the German installations are comparable with American practice as concerns steam pressure and steam temperature, those of Czechoslovakia employ considerably lower steam conditions. In most cases the ash content of the fuel is high.

The paper calls attention to the fact that conditions prevailing with a slagging-bottom furnace require, in addition to knowledge of the ash-fusion temperature, a study of the viscosity of the ash. To accomplish this several methods have been developed, but these in gen-

SLAGGING-BOTTOM BOILERS ERECTED AND PROJECTED IN CZECHOSLOVAKIA SINCE 1935

Plant Location	No.	Capacity, Lb/Hr	Pressure, Lb/Sq In.	Temp., F	Fuel, % Moisture	Ash	Vol.	Btu/-Lb	Milling System	Mfr. Furnace Boiler	In Operation	Type Boiler	Furnace
Parschnitz	1	66,000	227	750	2 4	17 33	24 32	12,100 10,100	2 Pneum-unit	Wiesner	1935	Sec. Hdr.	Single chamber
Zlin	1	132,000	568	825	15	12	..	7,900 7,600	3 Pneum-unit	Wiesner	1935	2-Drum bent-tube	Single chamber
Kolin	1 1	132,000 188,000	710 710	840 840	..	..	..	9,000 7,200	3 Pneum-unit	Wiesner CKD	1935 1944	2-Drum bent-tube	Single chamber
Bruenn	1	198,000	994	840	3 4	40 50	13 15	9,000 7,200	Loesche Storage	Bruenner Skoda	1938	2-Drum bent-tube	Double chamber
Pardubitz	1 1	88,000 132,000	667 667	840 840	6 6	30 45	16 25	9,000 8,100	3 Resolutor	Skoda	1938 1945	2-Drum bent-tube	Double chamber
Oslawan	2 1	132,000 264,000	610 610	840 840	3 4	4 50	13 15	9,000 7,200	Loesche Peters	Bruenner Skoda	1941 1944	Sect. Hdr., 2-Drum bent-tube	Double chamber
Ignaz	1	188,000	580	800	5 5	14 20	17 32	12,000 10,700	3 Pneum-unit	Skoda	1944	2-Drum bent-tube	Double chamber
Orlau-Lazy	3	132,000	667	840	5	14	17	12,000	Tube Mills	Skoda	1945	2-Drum bent-tube	Double chamber
Kladno	1	132,000	923	840	14	20	..	7,200	......	Skoda	1945	....	Double chamber
Nachod	1	132,000	910	840	..	..	..	....	......	....	Proj.	....	....

eral, require rather complicated apparatus and procedure; hence can hardly be considered practical for design purposes. K. Endell and several co-workers[1] were for some years engaged in research directed toward the discovery of a definite relationship, within predetermined temperature limits, between the viscosity and the chemical analysis of the coal slag. As a result of this work, the following equation was developed:

$$K_z = \frac{SiO_2 + 0.5\,(Al_2 + K_2O)}{0.5\,(Fe_2 + FeO + CaO)} + MgO + Na_2O$$

where K_z represents the viscosity number in per cent by weight.

This viscosity formula has been simplified to permit a more rapid yet close approximation of the slag viscosity, so that $K_z = 0.5\,(Fe + CaO) + MgO$, in per cent by weight.

The author concludes with the observation that critical surveys of the advantages and disadvantages of the slagging-bottom furnace bring out clearly that its selection is mainly governed by the character of fuel available, since this type of firing is best adapted to low-volatile, high-ash coal burned in boilers of larger than 200,000 lb per hr output and operated under relatively constant high load conditions.

[1] "Temperature-Viscosity Relationship of Coal Slag," by K. Endell, C. Wens, P. Rosin and R. Rehling, Special Edition No. 12 to *Angewandte Chemie* and *Die Chemische Fabrik*, Berlin, 1935.

A.S.M.E. Spring Meeting at New London

POWER subjects occupied a prominent place on the program of the A.S.M.E. Spring Meeting held at New London, Conn., May 2–4. These included a session with several papers on marine fouling and its control; a fuels session dealing with stoker firing, overfire air and the prevention of slag deposits on heating surfaces; as well as individual papers on the extension to the English Station in New Haven and on the latest applications of the mercury-steam cycle.

Addressing the welcoming luncheon, **Harry R. Westcott,** president of Westcott & Mapes, Inc., New Haven, Conn., urged engineers to lower prices as a palliative for recession. Planning is needed to encourage lowering of price levels and is a responsibility of management. Noting that foreign competition is just being felt, the speaker anticipated that it would be even keener in the future. The engineer has a duty both through his professional society and his individual business to reduce prices if he is to contribute to the prosperity of tomorrow.

At the Tuesday luncheon, **I. E. Moultrop** reviewed progress in power plant practice since 1892, when he entered this field, and offered some predictions as to the future. In the early '90's hand firing predominated, coal in Boston cost $2.30 a ton and the fuel rate was about 9½ lb per kwhr. It was just prior to 1900 that condensing stations began to appear. He credited rivalry among members of the Prime Movers Committee for much of the later progress in central station practice.

As to the future, he believed the gas turbine to have excellent opportunities within its size limitations; foresaw the possibilities of eventually using solar energy for space heating; and was of the opinion that, despite a long hard road ahead, atomic energy would ultimately find its place in power generation.

The English Station Extension

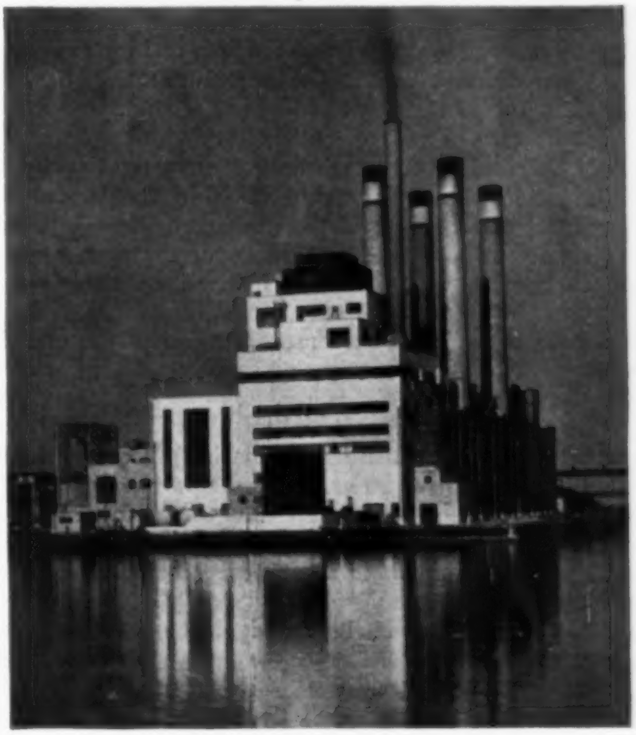
Features of the postwar extension to the English Station of the United Illuminating Company, New Haven, Conn., were described in a paper by **R. L. Anthony** and **J. O. Mullen** of Westcott and Mapes, Inc., and **C. A. Molsberry** and **E. H. Walton** of the United Illuminating Company. To the existing station, consisting of twelve stoker-fired boilers and six 12,500-kw turbine-generators, has been added a unit boiler-turbine plant of 30,000-kw capacity.

Because of the nature of the electrical distribution system, station design and operation is more characteristic of that required for isolated plants than that needed for large interconnected systems. Further restrictions on design were imposed by the physical limitations of the site and the amount of cooling water available for condenser service.

The radiant type boiler is equipped to burn pulverized coal or heavy fuel oil and has a continuous output of 320,000 lb per hr at 900 psig and 910 F. The turbine-generator is a 30,000-kw, 3600-rpm, Preferred Standard machine and exhausts to a 27,500-sq ft single-pass surface condenser. At full load the anticipated overall heat rate is 11,400 Btu per kwhr.

One of the features of the plant is the extent to which centralized control has been installed. Turbine, boiler and feedwater panels form the walls of a control room placed between the boiler and turbine. Two men are normally stationed at these panels, where they have inside and outside telephones as well as a Selsyn signalling system connected to the main electrical distribution control room.

Electric heating is utilized for the 2000-ft transfer line from the main heavy fuel oil storage tank to the storage tank near the station. The line is sectionalized into 190-ft lengths which form the secondary circuits of stepdown transformers and are heated by the internal resistance of the pipe when current is passed through them at a potential of about 20 volts.



English station; extension in foreground

A study was made of condensing water temperatures for the purpose of determining the feasibility of installing additional generating equipment at the same location. Special consideration was also given to operation of the station under flood conditions and at times when the supply of city water might be impaired.

The Modern Mercury Unit

A paper by **D. Douglass,** of the Hartford Electric Light Company, and **H. N. Hackett,** of General Electric Company, outlined the theory of the mercury-steam cycle, particularly as applied to topping plants, and

compared the relative capabilities of 140 psig mercury with 2300 psig steam. The recent new installation of a 15,000-kw mercury unit at the South Meadow Station of the Hartford Electric Light Company was described in detail and reference was made to three 7500-kw units for the Pittsfield and the Schiller power stations, the latter at Portsmouth, N. H.

Based on operation since February 1, 1949, when the South Meadow unit was completed, performance to date has shown a net station heat rate of 10,200 Btu, or a fuel rate of 0.588 lb of oil per net kilowatt-hour.

Marine Fouling Problems

Experiences with marine fouling in a power plant at Lynn, Mass., were enumerated by **I. A. Patten,** superintendent of Lynn Gas & Electric Company, in a paper entitled "Project Study for the Mitigation of Marine Fouling."

In 1927, a concrete intake water tunnel was designed, approximately 250 ft in length and 7 ft square near the intake, with progressively decreasing cross-section. Since there is but one tunnel, cleaning can only be accomplished by shutting down the main tunnel and employing inadequate bypass connections for circulating water requirements. The maximum rate of flow in the tunnel is on the order of 3 ft per second.

After nearly a year of satisfactory plant operation, condenser fouling occurred, and an investigation by a diver disclosed a heavy congestion in the tunnel of Mytilus (common mussels), Tubularia (sea moss) and Metridia (sea anemone). These growths were firmly attached to the walls and roof of the tunnel and were most plentiful near the intake. As a result it was often necessary to clean the condensers as frequently as once a week, with resultant station losses in generating capacity.

The tunnel was dewatered in 1931, and approximately 160 tons of mussels and marine growth were removed in a period of 20 hr at a cost approaching $6000 for equipment and labor. At that time it became apparent that the process would have to be repeated annually unless some new means of controlling marine fouling could be found.

The first preventive to be tried against mussel development was chlorine. After a few months of operation little improvement was noted, and the treatment was discontinued pending study and evaluation of the many unknown factors involved. An attempt was also made to electrocute various types of marine growth by submerging two framed wire grids in the forebay outside the screen wall, but due to lack of equipment this experiment was discontinued after five months without finally determining the merit of the scheme.

From 1932 to 1944 tunnel cleaning continued annually each fall. In 1945, studies to eliminate marine growth were resumed, and it was decided to try chlorine with intermittent injection. After a year's experience with chlorination, part of which was on automatic control, the tunnel was inspected. Nearly as many mussels were found as in previous years, but the average size was much smaller, and Tubularia and Metridia had materially decreased. At the same time better vacuum was secured due to cleaner condenser tubes and less fouling of condensers.

During the winter of 1946–47, a pilot tunnel was constructed to simulate conditions in the main tunnel. Identical chlorinating programs were carried out in both tunnels. A Plankton net for trapping live organisms was tried, but results were unsatisfactory, probably due to the low velocity of flow. The idea of thermal treatment was also considered but was rejected because of its impracticality under existing physical conditions of the station.

Some of the beneficial effects of the experiments with chlorine are indicated by the November cleanings which produced 331 tons, 107 tons and 16 tons in 1945, 1946 and 1947, respectively. In reviewing progress to the end of 1947, there were several favorable factors for continued use of chlorine–progress in mussel control, no indication of corrosion-erosion of condenser and related equipment and reduced maintenance costs for condenser fouling. The single unfavorable factor was lack of full mussel control.

A few months later the decision was made to undertake a program of continuous chlorination, and decided improvement was noted. Mussels were widely scattered and of very small size; their attachment to the walls was rather weak, and on the floor almost all were found dead. It was estimated that the amount of marine growth present would not exceed two tons thereby making tunnel cleaning unnecessary. Chlorine effectiveness in the main tunnel was closely reproduced in the pilot tunnel, where walls in contact with chlorinated water were almost completely free from fouling attachment. The problem of marine fouling at the Lynn plant has not been completely solved, but a degree of control has been achieved which assures satisfactory operation with a reasonable degree of economy.

Laboratory Tests of Marine Fouling

H. E. White of Stone & Webster Engineering Corporation presented a comprehensive paper on experimental tests of marine fouling under the title of "Control of Marine Fouling in Sea Water Conduits and Cooling Water Systems Including Exploratory Tests on Killing Shelled Mussels." Outlining conditions which led to the project, the speaker also described the procedures of laboratory testing and its correlation with results observed in the field. An interesting series of curves was plotted showing the effect of moderate temperature change on time for killing shelled mussels, with and without continuous chlorination.

The following general technical conclusions were reached:

1. Usually the most troublesome form of marine fouling in the stationary conduit is the common mussel.
2. For complete disposal of marine fouling it is necessary under usual conditions of commercial operation to kill mussels after their shells are fully developed.
3. Under all conditions tested a large proportion of the mussels are killed within a fraction of the time required for killing all. This is significant because in a power station circulating water tunnel it is desirable, if mussels have accumulated, to remove them gradually so as to prevent clogging by sudden release and accumulation of uncontrolled masses of debris.
4. The chlorine consumption required to kill shelled mussels can be greatly reduced by moderately increas-

ing the temperature of the water during chlorination.

5. The time required to kill shelled mussels by chlorination depends primarily upon the temperature of the water in which they are submerged at the time of chlorination. This is a much more significant factor than the variations of the concentration of the residual chlorine within the usual commercial range.

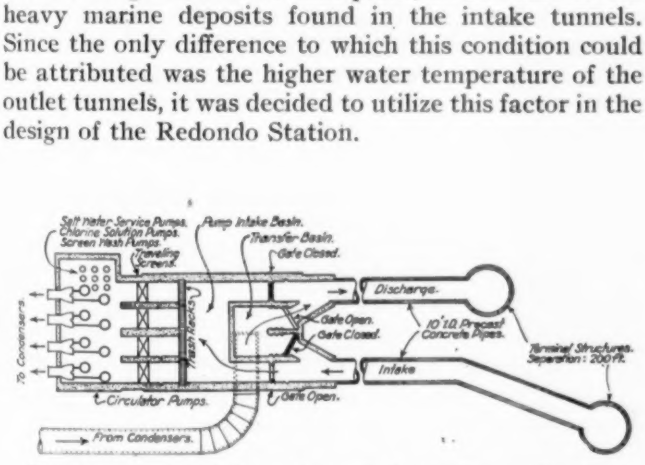
6. The most significant reduction in chlorine consumption by increasing the temperatureof the sea water is obtained at the lower temperatures and for moderate temperature increases.

7. Complete killing of shelled mussels may be accomplished by the application of moderate increase in temperature alone, with no chlorine or other chemical agent, if continuously applied for sufficient periods.

8. There are logarithmic relationships between the time required for complete killing and temperature of sea water during killing treatments.

Temperature Control of Marine Fouling

A paper describing the system of marine fouling control at the recently constructed Redondo Steam Station was presented by **W. L. Chadwick** of the Southern California Edison Company, **F. S. Clark** of Stone & Webster Engineering Corporation, and **Dr. D. L. Fox** of Scripps Institute of Oceanography. Observations at the Long Beach Station of the Southern California Edison Company revealed that no fouling growths had occurred in the discharge tunnels of that plant, in contrast to the heavy marine deposits found in the intake tunnels. Since the only difference to which this condition could be attributed was the higher water temperature of the outlet tunnels, it was decided to utilize this factor in the design of the Redondo Station.



Discharge and intake system, Redondo Steam Station

As shown in the accompanying figure, two 10 ft ID precast concrete pipes are laid in the floor of the beach and extend into the sea about 1900 ft. The shore end of each concrete pipe is connected to a concrete structure in which there are four vertical steel gates which can be raised or lowered with electric motors. The gates are arranged and operated so that one of the concrete pipes acts as an intake and the other as a discharge conduit. At intervals the position of the gates is changed so that flow is reversed in each conduit, making it possible to use either alternately as a discharge or intake.

The reversal of the circulating water is effected by four vertical gates, one located in each intake and two at the outlets of the transfer basin or reversing chamber. The gates are electrically operated and will normally operate in pairs, one intake and one discharge opening, the other pair closing. For a short period following tunnel reversal, condensers will receive warmer than normal circulating water, but it has been found from experience that this condition does not affect the ability of the main units to carry full load.

Laboratory investigations at the Scripps Institution of Oceanography indicated that the bay mussel (Mytulis edulis) was most resistant to elevated temperatures and that means for eliminating it would be effective for other marine organisms as well. Tests disclosed that after 100 F is reached the mussel dies within one hour and that its reproductive cycle ceases when ocean temperature drops below 60 F. During the months when ocean water exceeds 60 F, the gate positions are reversed periodically so that the line which acted as the intake now becomes the discharge. Limited recirculation is permitted until the water in the discharge line is raised to 102 F, at which point it is maintained for four hours before restoring the gate to normal position and stopping recirculation. Recirculation has been carried out at intervals ranging from ten days to three weeks, and it appears that the latter is sufficient, with the possibility that a further increase between reversals may be feasible.

The pipes were subjected to the previously described treatment during the summer of 1948 and have remained free of fouling organisms. Examination of conditions in the interior of the pipes was made at least once a month and concrete test panels were hung in the pipes to verify the effectiveness of the method. The operating cost is relatively small, particularly in comparison to the alternative of using chlorine in lethal quantities. While some additional capital expenditure was necessary to provide facilities for periodically reversing water flow, it is judged that the fixed charges on these are considerably below the estimated annual expense for chlorine.

Slag Deposits on Heating Surfaces of High-Pressure Boilers

E. F. Walsh, assistant superintendent of power plants of the Narragansett Electric Company, Providence, related experience with a large three-drum boiler operating at 1215 psi, 920 F, fired with fuel oil and pulverized coal as combined fuels and each fuel separately. During the first year no troublesome slagging conditions were encountered, but during the second year slag conditions in the superheater became a serious problem. Hand lancing at frequent intervals were necessary and it was never possible to thoroughly clean the superheater during operation. Even within two months after the unit had been down and subjected to mechanical cleaning, severe fouling again occurred.

The slag consisted of two layers, that adjacent to the tubes being the result of pulverized coal and oil firing, whereas the outer layer appeared definitely to have resulted from the type of fuel oil that was being burned. The following remedial measures were adopted:

During the annual overhaul period of 1947, soft water from a hot-process softener, with a pH of not less than 11 and a PO_4 content of not less than 10 ppm, was

sprayed on the slag for about 8 hr. The slag absorbed sufficient water to dissolve the binder between the metal surface and the slag, thus making it easy to remove. After all had been removed, the tubes were washed with alkaline water until the acid in the pores of the metal was completely neutralized. The same treatment was given the induced-draft fan, the air preheaters and the ductwork.

A lime slurry was then prepared and sprayed over the metal surfaces with a paint gun.

The boiler was then put back in service and operated a year without any appreciable deposits.

By way of explanation, it appears from experience that new boilers are usually immune to objectional deposits for varying periods depending upon the fuel; or until the metal surfaces have become saturated with sulfuric acid, no serious slag conditions are encountered. It is therefore important to thoroughly wash and neutralize the surfaces when the boiler is out for inspection and cleaning—once a year usually being sufficient. The presence of sulfuric acid on the surfaces increases the dew point and causes the ash in the flue gases to adhere to the metal, and the process becomes accumulative; but the application of lime slurry, after neutralization, provides a needed protective coating.

Stoker Firing

After reviewing the role of large multiple-retort underfeed stokers in the period from 1910 through the '20's when the feud between pulverized coal and stoker adherents led to much "over-reaching" on both sides, J. S. Bennett, vice president, and F. C. Messaros, chief engineer of American Engineering Company, summed up the present status with the statement that "few engineers today would fail to consider stokers for boilers with capacities below 200,000 lb per hr, but stoker-fired boilers of 300,000 lb per hr are rare."

The spreader stoker was quoted as the "Glamour Girl" of the combustion field. This type, while very old, did not come into extensive commercial use until the '30's when its low first cost, ability to burn poor coals, and general freedom from operating troubles led to its wide adoption. Better engineering and the development of cinder return and overfire devices increased its popularity. The subsequent introduction of the continuous ash-discharge type of grate increased spreader stoker capacities rapidly, and many such installations have been made for steam outputs of 30,000 to 200,000 lb per hr. They give excellent performance with a very wide range of coals, with high efficiency, freedom from clinker problems and almost negligible combustible in the ash.

Since a large proportion of the coal is burned in suspension, considerable solid material is entrained in the gases that leave the furnace, but much of this is coarse and drops out in soot hoppers below the rear of the unit. Most of the remainder is coarse enough to be trapped in a comparatively inexpensive cinder collector. The usual practice is to return this material, containing unburned carbon, to the furnace for reburning.

The importance of overfire air in reducing carryover and providing furnace turbulence is now well established, but the benefits are largely dependent upon the proper application and design of the nozzles.

Other observations by Messrs. Bennett and Messaros concerning spreader stokers included the following:

Little is yet known of the effect of preheated air on spreader stoker firing.

Smoke must be given special attention on large units, if burning rates are stepped up.

Effective use of high-pressure air for cinder return may be had by the use of venturi fittings, but a separate line to the furnace from each cinder drain should be used.

Much higher coal burning rates may be obtained with coals of low calorific value.

Finally, to overcome certain limitations in length, Messrs. Bennett and Messaros proposed firing across the furnace, believing that by this means a coal burning rate of 2500 lb per hr per ft of furnace width might be practicable.

Furnace Performance with Overfire Jets

Tracing the development of overfire air systems, **William S. Major** of Bituminous Coal Research, Inc., pointed out beneficial effects in reducing air pollution. Although overfire jets for improving combustion and abating smoke have been used for many years, with various degrees of success, the extensive adoption of jets has taken place during the last ten years.

Studies have shown improvements in furnace performance on all types of stoker-fired and hand-fired furnaces by the application of overfire jets. It is the opinion of the author that maximum benefits from jets are most likely to occur on spreader-stoker-fired furnaces, where there is a greater tendency for gas stratification when not provided with auxiliary turbulence from jets. Improvements with overfire systems that have occurred on various types of furnaces include: (1) substantial reduction in smoke density; (2) increases in boiler and furnace efficiency (up to about 7.5 per cent with spreader stoker firing); (3) reduction of both the quantity and carbon content of cinder carryover; (4) shortening of the flame and reduction of the final temperatures when surfaces are of the same degree of cleanliness; (5) reduction of soot and slag deposits on boiler and economizer surfaces; and (6) ability to operate with slightly lower excess air without unburned combustible gases.

Kreisinger Laboratory Dedicated

On April 22, 1949, the Kreisinger Development Laboratory, located at the Chattanooga Plant of Combustion Engineering-Superheater, Inc., was dedicated by J. V. Santry, president of the Company. In attendance for the ceremony were members of the Power Generation Committee of the Association of Edison Illuminating Companies, prominent business and government leaders of Chattanooga, and executives of Combustion.

Telling how the late Henry Kreisinger emigrated to this country from Bohemia as a youth of fifteen, Mr. Santry paid tribute to the memory of an engineer who had contributed greatly to the development of pulverized fuel. At the conclusion of the ceremony a photograph and bronze plaque were unveiled. The inscription on the plaque reads as follows:

"This laboratory is dedicted to the memory of Henry Kreisinger, engineer-scientist-teacher. A pioneer who made major contributions to the science of fuel burning and steam generation. A profound thinker who sought only to find the truth and apply it to the advancement of practice in the field he served. A simple, modest and lovable man. Director of Research, Combustion Engineering Company, Inc., 1920–1946."

J. V. Santry, president of Combustion Engineering-Superheater, Inc., unveiling photograph of Henry Kreisinger and bronze plaque.

After coming to America in 1891, Mr. Kreisinger worked in various machine shops for a period of nine years, attending evening school at the same time. He then entered the University of Illinois from which he obtained a B.S. degree in 1904, and an M.E. degree in 1906. For several years thereafter he was associated with Professor L. P. Breckenridge in an extensive series of fuel tests conducted by the U. S. Geological Survey at St. Louis, Norfolk and Pittsburgh.

In 1913, Mr. Kreisinger became associated with the Bureau of Mines as supervising engineer of the fuel section where he conducted investigations dealing with the combustion of all types of fuel and with the transfer of heat in steam boilers. Joining the Research Department of Combustion Engineering Company in 1920, he devoted most of his time in the early years to the development of pulverized coal firing and the use of water cooling in furnaces. In 1920, in cooperation with the Bureau of Mines, he conducted a long series of tests on the pulverized-coal-fired boilers at the Oneida Street Station of the Milwaukee Electric Railway & Light Company.

Mr. Kreisinger's work for Combustion in later years included supervision of research and testing with respect to all types of fuel-burning equipment, investigations of furnace temperatures and heat absorption in steam generating units, steam purification problems and many related subjects. Planning for the Company's new development laboratory occupied much of his time during his latter years and before his death in May 1946, he was able to see many of these plans nearing completion.

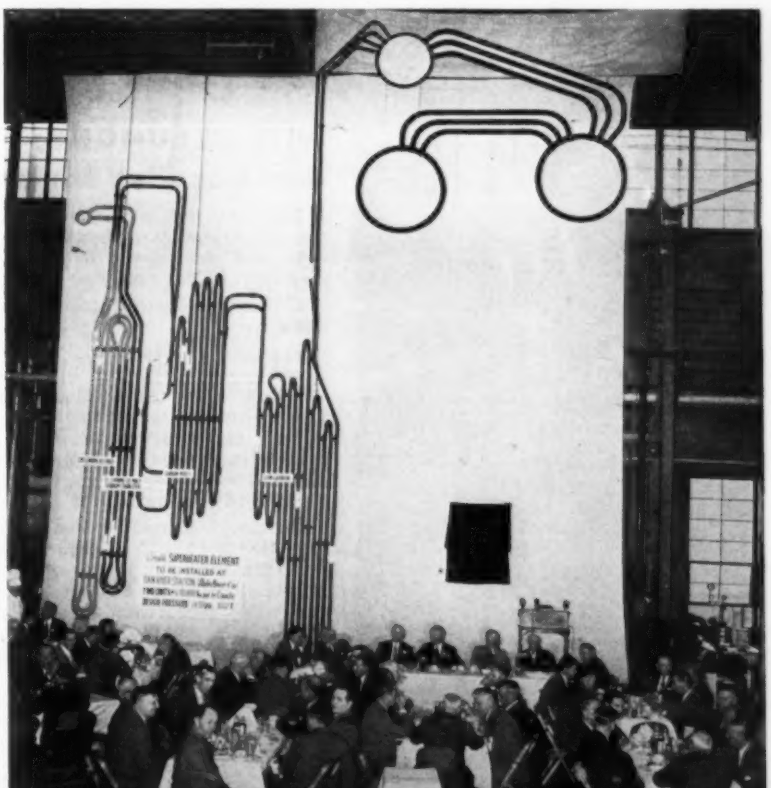
In 1943, Henry Kreisinger received the Percy Nicholls Award which is presented jointly by the A.I.M.E. and A.S.M.E. for notable scientific or industrial achievement in the field of solid fuels.

The Kreisinger Development Laboratory, shown on the cover of this issue, consists of two buildings, one being the laboratory proper which is a modern steel building 80 ft wide by 120 ft long. The other is an adjoining brick building which houses the offices and the physical and chemical laboratories.

The first section of the laboratory was built in 1942. Construction of the second section and the brick building was begun after the war and was completed in December of 1946. For use in experimental and test work, the main building has its own marine-type sectional header boiler to supply steam and a traveling crane to handle heavy equipment.

The physical and chemical laboratories are equipped to handle routine testing for experimental work done in the field as well as at the laboratory. Facilities are also available for overhauling and calibrating test instruments used for field-testing purposes.

Tests and experimental work on the following projects have been undertaken since the completion of the laboratory: investigation of flow characteristics of mixtures of pulverized coal and air, stoker burning of wood and rice hulls, studies of steam purity and development of steam drum internals, proportional limit header tests, pitot-tube calibrations, cyclone dust collector development and performance tests of smaller designs of water-tube boilers and electric boilers. The laboratory also has been engaged in an extensive research and development program of a classified nature for the United States Navy.



Luncheon during dedication ceremonies attended by members of Power Generation Committee, A.E.I.C.

Synthetic Fuel Oil Costs

The following excerpts are from a recent Bureau of Mines Report of Investigations 4413, entitled "Estimated Cost of Producing Heavy Fuel Oil by the Hydrogenation of Coal," by L. L. Hirst, L. C. Skinner, E. A. Clarke, R. W. Dougherty and H. A. Levene.

Certain advantages are possessed by liquid fuel oils over solid fuels. These include ease in handling, precision temperature control, minimum amounts of ash and greater storage of heating units in a given cubic volume, particularly where space is limited.

The principal sources of heavy fuel oil at present are petroleum refinery residuum and coke-oven tars and pitches. Between 1937 and 1947, there was a 59 per cent increase in annual domestic consumption from 325,000,000 barrels to 517,000,000 barrels. However, there is a current trend toward increasing the distillate oil and gasoline yield from petroleum at the expense of heavy fuel oil production. From 1945 to 1947, the proportion of residual to total fuel oils dropped from 63 per cent to 51 per cent, and it is expected to drop to about 45 per cent in 1952. As the demand for distillate oil and gasoline increases, there may be further scarcity of heavy fuel oil and a tendency to increase the price of residual fuel. If the present price structure of fuel oil and coal continues, it appears that fuel oil from coal can supply part of the demand and may be an effective means of supplementing residual fuel oils from petroleum.

The Bureau of Mines Office of Synthetic Liquid Fuels, recognizing the necessity for a dependable supplementary source of heavy fuel oil, has studied possible methods of synthetic fuel oil production. Although it is recognized that shale oil will provide a possible alternate source of heavy fuel oil in certain localities, the Report, which has as its objective the estimation of the investment and cost of production of heavy fuel oil from coal, is limited to the use of coal as a raw material.

Direct hydrogenation and combination of hydrogenation with extraction of coal were the two processes selected for the investigation. Plants using each of these processes were assumed to be adjacent to the coal supply or at a location where an ample supply of coke-oven gas for hydrogen make-up is available. Estimates of investments and production costs for the four processes were made for purposes of comparison.

As a result of the study it appears economically justified for some localities to produce synthetic fuel at present price levels. If the cost of residual fuel oils continues to increase, production of synthetic fuel oil may become increasingly attractive in other localities.

From the study it was determined that the cost of all facilities, except steam and power generation, to produce heavy fuel oil by the hydrogenation of coal will vary between \$5800 and \$7500 per daily barrel of fuel oil produced, for plants of about 10,000 barrels per day capacity. For larger plants there would be some reduction in investment cost.

With coal at \$3.00 per ton the cost of fuel oil from plants of this size would range from \$3.07 to \$4.16 per barrel. To this amount would have to be added the freight costs of coal and oil, and the cost excluding profit might therefore range from \$4.33 to \$5.04 per barrel at the point of consumption.

Of the four process arrangements studied, most economical operation may be achieved by the hydrogenation-extraction process using coke-oven gas as a source of hydrogen. The next most economical operation appears to be the hydrogenation-extraction process at the mine, using coal gasification as a source of supplemental hydrogen. The most costly operation appears to be direct hydrogenation when hydrogen is produced by gasification of coal.

If technological improvements now under way fulfill their expectations and if the present trend toward higher crude oil prices continues, the large investment required to convert coal to fuel oil may soon be justified.

Among the Papers at San Francisco

Papers contributed by the Power, Fuels, and Petroleum Divisions of the A.S.M.E. for delivery at the Semi-Annual Meeting in San Francisco, from June 27 through July 1, include the following:

"Synthetic Liquid Fuels from Coal and Oil Shale," by **W. C. Schroeder,** chief, Office of Synthetic Liquid Fuels, U. S. Bureau of Mines—*Tuesday morning, June 28*

"Limitations in the Use of Sodium Sulfite for Oxygen Control in Boiler Feedwater," by **R. C. Alexander,** mechanical engineer, Harbor Steam Station, Los Angeles Department of Water and Power, and **H. K. Rummel,** chemical and consulting engineer—*Tuesday morning*

Symposium on "Experience in Chemical Control in Pre-boiler Water Systems of Central Stations on the Pacific Coast with Special Reference to Early Operations"—*Tuesday morning*

"Industrial Power Plant—Weyerhaeuser Timer Company," by **C. Dodge,** assistant chief engineer of the Weyerhaeuser Timber Company, and **C. W. E. Clarke,** vice president and consulting engineer, United Engineers and Constructors—*Wednesday morning*

"History and Performance of Pacific Gas & Electric Company's Oil Refinery Steam-Electric Generating Stations," by **V. F. Estcourt,** engineer of steam and gas operations, Pacific Gas & Electric Company—*Wednesday morning*

"Steam-Electric Power Expansion in Southern California," by **W. L. Chadwick,** manager of Engineering Department, Southern California Edison Company—*Thursday morning*

"Post-War Planning for Steam Capacity in Northern California," by **C. C. Whelchel,** chief, Division of Steam Engineering, and **W. R. Johnson,** Division of Hydroelectric and Transmission Engineering, Pacific Gas & Electric Company—*Thursday morning*

"Cylindrical Furnaces for the Petroleum Industry," by **O. F. Campbell,** Sinclair Refining Company—*Thursday morning*

"Some Recent Developments in Burning Wet Wood," by **Otto de Lorenzi,** director of education, Combustion Engineering-Superheater, Inc.—*Thursday morning*

"Design of Sewaren Generating Station and No. 1 Unit at Essex Station of the Public Service Electric and Gas Company," by **F. P. Fairchild,** chief engineer, Electric-engineering Department, Public Service Electric and Gas Company, Newark, N. J.—*Friday morning*

"Operating Characteristics of the 100,000-kw Essex Turbine-Generator," by **Stanford Neal,** section engineer, Steam-Turbine Engineering Division, General Electric Company, and **V. S. Renton,** Public Service Electric and Gas Company—*Friday morning*

"Heat Rate Test Results of the 100,000-Kw Essex Turbine-Generators," by **Stanford Neal,** General Electric Company, and V. S. Renton, Public Service Electric and Gas Company—*Friday morning.*

(*Continued on page 52*)

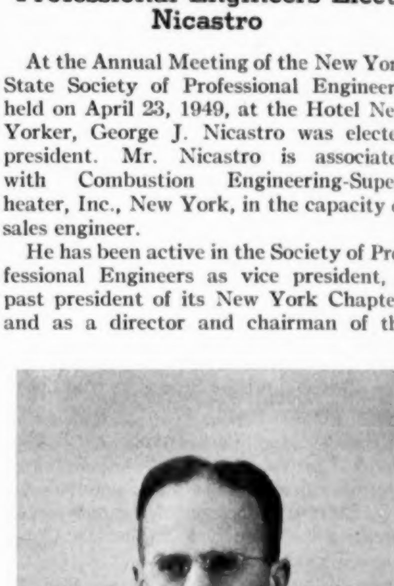
There will also be a summary on Thursday morning by **H. E. White,** of Stone & Webster, covering the four papers[1] on "Marine Fouling" which were presented at the Spring Meeting in New London, Conn.

Many other papers have been scheduled on subjects falling within the scope of various professional divisions, and a number of field trips are planned. Meetings will be held at the University of California Extension Building, San Francisco.

Professional Engineers Elect Nicastro

At the Annual Meeting of the New York State Society of Professional Engineers, held on April 23, 1949, at the Hotel New Yorker, George J. Nicastro was elected president. Mr. Nicastro is associated with Combustion Engineering-Superheater, Inc., New York, in the capacity of sales engineer.

He has been active in the Society of Professional Engineers as vice president, a past president of its New York Chapter, and as a director and chairman of the



Chapter Activities Committee of the National Society. The national membership of fully licensed professional engineers now totals 21,000. There are 23 chapters in the New York State Society, which has a total membership of 2700.

Mr. Nicastro is a graduate of Stevens Institute of Technology where he has been very active as a member of the Executive Committee, a director of the Alumni Association, and president of the Stevens Metropolitan Club. He is also a member and has served on many committees of the American Society of Mechanical Engineers.

A further honor has been accorded Mr. Nicastro by the Italian Historical Society of America in selecting him to receive this year's meritorious award, given to an engineer of Italian descent for outstanding achievements in his profession.

[1] For abstracts of these papers see report on Spring Meeting, pages 45–47 of this issue.

Smoke Prevention Association to Meet in Birmingham, Ala.

The Forty-Second Annual Conference of the Smoke Prevention Association of America is scheduled to be held in Birmingham, Ala., May 23 through May 27.

Following registration on Monday morning, that afternoon will be given over to a conference of smoke inspectors and a panel discussion on locomotive smoke problems.

On Tuesday morning President **W. G. Christy** will give the opening address, and there will be brief talks by the Mayor and by the Public Improvement Commissioner of Birmingham. Following these, **Dr. A. J. Lanza** will discuss "Medical Aspects of Air Pollution" and **A. L. Penniman,** of Baltimore, will talk on "Utilities' Viewpoint Regarding Smoke and Fly-Ash Elimination."

That afternoon there will be papers on "Operation of Incinerators to Dispose of Municipal Waste"; "Hot Gases from High Stacks as a Means of Overcoming Objectionable Concentrations of Effluent Gases"; and "Abatement of Smoke and Fumes in the Oil Industry."

"Air Pollution Problems of the Steel Industry"; "Prevention of Smoke, Fumes and Solids from Cupola Operation"; and "Locomotive Smoke Abatement" are topics listed for Wednesday morning. In the afternoon there will be a paper by **Robert Milligan** on "Operation of Stokers to Prevent Smoke," and a Panel Discussion of the A.S.M.E. Model Smoke and Dust Regulation Code. Taking part in this panel will be **John F. Barkley, Carroll Hardy, M. G. Stewart, Charles W. Gruber, Henry F. Hebley, Eugene D. Benton, Thomas C. Cheasley, Carl Mabley, E. B. Brundage** and **R. L. Wolf.**

The banquet on Wednesday evening will be at the Tutwiler Hotel.

Thursday's program calls for a paper by **W. S. Major** on "The Solid Fuel Industry's Contribution to Air Pollution Prevention"; and another by **Prof. J. R. Fellows** on "The University of Illinois Smokeless Stove." There will also be various committee reports and the business meeting.

The Alabama Power Company has invited members and guests to inspect the underground gasification experiment at Gorgas, Ala., on Friday.

Dedication of Hickling Station

On May 5, 1949, Ralph D. Jennison, chairman of the board of directors of the New York State Electric & Gas Corporation, dedicated the new Hickling Electric Generating Station located along the Chemung River at East Corning, N. Y. In his remarks Mr. Jennison paid tribute to the late William G. Hickling, who, as vice president and general manager of the Company, had an important part in the conception and design of the plant which bears his name.

Burning No. 4 buckwheat anthracite on traveling grate stokers, the plant is equipped with two Combustion Engineering steam generating units, each having a continuous capacity of 175,000 lb of steam per hour and designed to operate at 875 psig and 910 F. The initial capacity is 35,000 kw. Consulting engineers for the project were Gilbert Associates, Inc.

Personals

J. H. Williams has joined The Fairmont Coal Bureau as fuel engineer. A specialist in the design and construction of steam generating plants, he was formerly associated with the consulting engineering firms of Gilbert Associates, of Reading, Pa., and Burns & Roe, Inc., New York.

H. E. Leilich, formerly mechanical engineer and power plant project manager for the Rust Engineering Co., has joined the staff of the Peter F. Loftus Corp., engineering consultants of Pittsburgh.

Herbert B. Reynolds, after 35 yr with the Interborough Rapid Transit Co., and its successor, The New York City Transit System, in various capacities up to superintendent of power for the entire System, has retired and become associated with the J. G. White Engineering Corp., New York.

Frank V. Smith has retired after 29 yr with the Marine Division of General Electric Co. During this period he instructed many marine engineers in the operation of turbine propulsion equipment, lectured on the thermodynamics of marine power plants to Annapolis graduates and delivered similar series of lectures at Columbia University and other schools.

Frank M. Re Pass, Jr., has joined Manning, Maxwell & Moore, Inc., as development engineer for Consolidated safety and relief valves. He was formerly vice president of Crosby Steam Gauge & Valve Co., and more recently assistant sales manager of the J. E. Lonergan Co.

Robert E. Derby, for some years associated with the late Albert C. Wood, Philadelphia consulting engineer, will take over operation of the firm and carry on its work as before.

Obituaries

Harry A. Brinkerhoff, well-known construction and managing engineer, died at his home in Brooklyn, N. Y., on May 1, at the age of 78.

His earlier associations included such well-known engineering firms as Westinghouse, Church, Kerr & Co., United Engineers and Constructors, Stovel & Brinkerhoff, F. H. McGraw & Co., the Chemical Construction Co., and for the last three years Baker & Spencer, consulting engineers, New York. Interspersed with his strictly engineering connections were a four-year term from 1924 to 1928 as city manager of Portland, Me., and later a similar position in South Portland.

Albert C. Wood, Philadelphia consulting engineer, died March 13, at the age of 74. Shortly after graduation from the University of Arkansas, Mr. Wood came to Philadelphia to enter the engineering office of J. J. De Kinder, and in 1902 set up his own office specializing in the design of power plants for various industries, as well as municipal plants. He was a Fellow of the A.S.M.E., as well as a member of the A.I.E.E. and the Society of Professional

Engineers. Albert was a brother of two other well-known engineers in the power plant field, the late Walter Wood of Combustion Engineering Co., and the late Benjamin F. Wood of Stevens & Wood.

Walter F. Welsh, long connected with the Bigelow-Liptak Corp., as sales engineer, died recently as the result of a stroke suffered while returning from his vacation in Florida. He was a member of the Engineering Society of Detroit and the Michigan Engineering Society.

Business Notes

Russell C. Jones, president of **The Griscom-Russell Co.** since 1939, and associated with the Company for 40 yr, retired as president on April 30, 1949. He is succeeded by Kenneth B. Ris, formerly vice president in charge of sales.

W. G. Arnold has been appointed works manager of **General Electric Company's** Fitchburg, Mass., Works. In addition to his new duties he will continue in his present capacity as manager of manufacturing for the turbine and welding divisions, located at Fitchburg.

L. W. Clarke, formerly general sales manager of the **Philip Carey Mfg. Co.,** Cincinnati, O., was elected vice president in charge of sales of that company at its board of directors annual organization meeting held recently. He succeeds E. W. Smith who resigned.

Peabody Engineering Corp., New York, has appointed Robert C. Vroom to the position of executive advisor and consultant. For many years as chief engineer, he was identified with developments and pioneer work of that company and his new duties will concern particularly planning, procedure and overall policy.

Hagan Corporation, Pittsburgh, has appointed W. J. Osborn as district manager for the Company at San Francisco, succeeding Clyde F. Williamson, who resigned. Mr. Osborn has been with the organization since 1940. Also, Alfred Pittman, a veteran marine engineer of 30 yr experience, has been appointed marine manager at the San Francisco Office.

The Carborundum Co. announces the following changes in district sales office personnel:

R. P. Colosi, from the Buffalo District Sales Office, to be manager of the Cleveland District Sales Office succeeding H. P. Erbe, who is now office manager at Pittsburgh; H. E. Morrill, supervisor, Branch Inventories, has been promoted to manager of the Chicago District Sales Office, to succeed R. J. Nemec, who becomes manager of the St. Louis District Sales Office, succeeding A. L. Fischer.

Combustion Engineering-Superheater, Inc., announces the following appointments in its Sales Department:

Walter Springe, division manager, Kansas City, Mo.

C. J. Grossi, district manager, Tulsa, Okla.

T. E. McMahon, district manager, Kansas City, Mo.

W. J. Woodruff, district manager, St. Louis, Mo.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

How to Keep Invention Records

By Harry A. Toulmin, Jr.

The text discusses in easy readable non-technical language the high spots of patent technique and particularly emphasizes to members of the bar, inventors and corporations the grave necessity of keeping adequate records of their valuable industrial property, known as inventions, the monopoly of which they are seeking for a period of years.

In the first part of the book the general nature of industrial property and monopolies granted to protect it are discussed, comprising such general fields as patents and copyrights. A discussion of foreign protection is also included.

In the second part a system is formulated based on the statutes as interpreted in numerous court decisions, to determine accurately the first user or inventor, and a practical method of insuring the recording of necessary dates is presented in a series of a dozen forms. These forms include Summary Card, Preliminary Sketch Sheet, Research Record, Drawing Form, Construction Record Sheet, Test Record Sheet, Statement by Witness, Photographic Record Form, and others.

The final part deals with methods of patent investigation discussing briefly points such as Anticipation of an Invention, Purchase of Patents, Infringement, Validity of the Patent, Title, Investigation before Invention, etc.

The volume should serve as useful guide to inventors, engineers, business men and executives in avoiding much litigation or where litigation cannot be avoided in saving thousands of dollars by keeping adequate records of inventions, their development and early commercial history.

There are 78 pages and the book is priced at $2.50.

The Steam Boiler Yearbook and Manual

Edited by Sydney D. Scorer
Fourth Edition

This represents a comprehensive guide to steam engineering practice in Great Britain. Power plant equipment that is in wide use is described in extensive detail and in many cases is illustrated by manufacturers' drawings or by installation photographs.

There are two parts to the book, Part I being devoted to a descriptive review of current British boiler plant practice. Part II, which makes up about 20 per cent of the text, contains extracts from articles and papers relating to contemporary developments of interest to operating engineers.

Part I constitutes the greater portion of the book and describes in detail various products made in Great Britain for boiler plant use. American readers may be surprised to note the extent of similarity in designs here and abroad. Many familiar trade names and much equipment that is in service in this country are also found listed and described in "The Steam Boiler Yearbook and Manual." Some of the chapter heatings in Part I are Combustion Appliances, Pulverized Fuel, Oil and Gas Firing, Boiler House Instruments, The Vertical Boiler, Locomotive and Internal-Flue Boiler Types, Waste Heat and Water-Tube Boiler Types, Special Water-Tube Boiler Types, Superheaters, Air Preheaters, Boiler Mountings and Accessories, The Removal of Boiler Deposits, Steam Pipes and Appliances, and Heat Insulation.

The chapters making up Part II are Combustion and Fuel Utilization, Boiler Operation, Feedwater Treatment, and Modern Boiler Practice and Developments.

There are 589 pages and the price is $7.00.

Patent Law

By Chester H. Biesterfeld

This book, intended for researchers, chemists, engineers, patent attorneys and inventors, affords the general reader an understandable treatment of each of the major subjects making up the field of patent law. Such treatment is supported by citations and quotations taken from court decisions, with special emphasis placed on cases decided during the past ten years.

Chapter headings include Invention and Discovery, Novelty, Priority of Invention, Originality, Abandonment, Chemical Claims, Functional Claims, Uses and Products of Nature, Double Patenting, Reissues, Disclaimers, The Patent Application and Prosecution Thereof, Interferences, Infringement, Licenses, Ownership and Shoprights, Trade Secrets, Patent Litigation and Searches.

Of particular interest is the author's comment on the strict manner in which the courts are now construing the patent statutes and the possibility that the way of the inventor has been made too hard. His opinion, however, is that on the whole the Federal courts seem not to have been too strict. Mr. Biesterfeld's analysis of recent cases shows that the courts still try to protect the inventor when he presents in his patent a meritorious discovery or invention; but that they are equally zealous in protecting the public in its right to practice the prior art and equivalents thereof, together with all modifications and developments that those skilled in the modern industrial arts are able to accomplish without an exercise of that unique effort of the mind known as "invention."

The book is well written and can be read with advantage by patent attorneys, inventors and others who deal with the preparation and prosecution of patent applications or who are engaged in engineering research and development. It contains 267 pages and is priced at $4.

Standards

Because of the costly restrictions suffered by many industries from out-of-date and non-uniform local regulations, a committee of the American Standards Association is issuing an analysis of the question, "How can nationally recognized standards legally be used in state laws and local ordinances?" The committee at present is making no recommendations but hopes that the booklet will bring comments and suggestions that may help to solve the problem. Every industry or group that has found its business hampered by varying local requirements and by regulations that make it necessary to supply out-of-date or non-standard materials will be interested in studying the suggestions offered by a group of experts. Those interested are invited to send their comments to the American Standards Association.

Four principal papers are included in the booklet, "Nationally Recognized Standards in State Laws and Local Ordinances." They show how lack of uniformity in technical requirements increases costs to industry and to the public, and reduces public safety; they analyze the need for legal methods that will permit widespread use of nationally recognized standards; summarize the present status of the "adoption by reference" method; and discuss the legality of several methods that have been followed in using national codes and standards as a basis for local regulations.

Single copies of the booklet at $1 each, and to ASA members at 85 cents each. More than 50 copies are priced at 70 cents per copy. They are obtainable from American Standards Association, 70 East 45th Street, New York 17, N. Y.

Reference Bibliography

Gilbert Associates, Inc., engineers and consultants, have compiled a bibliography for water, sewage and power plant engineering. Its purpose is to present a handy reference to pertinent information on these subjects by listing titles, authors and publishers of books, pamphlets and periodicals. United States Government publications, foreign publications and a selected list of manufacturers' literature are included. These are all properly grouped and covered by indices to subjects and authors. Addresses of engineering societies are appended.

This brochure is being offered gratis to interested parties whose request should be addressed to Gilbert Associates, Inc., Box 1498, Reading, Pa.

NEW CATALOGS AND BULLETINS

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Automatic Filter

The Dollinger Corp. has brought out an 8-page bulletin describing "Staynew" Model A-3 automatic filter. This equipment is designed for both average ventilation and air conditioning and heavy duty industrial service where relatively large volumes of air are to be filtered. Performance data and a capacity and dimension table are a part of the bulletin.

Condensate Return Systems

Publication No. 3250 of the Cochrane Corp. presents data on steam flow conditions and heat exchange characteristics of interest to engineers responsible for the efficient transfer of steam heat in heating, cooking, drying and pressing operations. The 24-page bulletin describes Cochrane condensate return systems for operation under differential pressures up to 200 psi. Dimensioned drawings in color show the design and construction of the drainage control units, and there are tables of capacity ratings.

Dust Collectors

A series of twelve advertisements relating to dust collecting equipment has been reprinted by the American Blower Corp. Methods of laboratory testing are illustrated, and installation views are presented. There are also photographs of the manufacture and assembly of dust collecting equipment. Applications of this equipment are found in cement plants, steel mills, asphalt plants, machinery and grinding shops and power plants.

Electronic Alloys

The International Nickel Co., Inc., has released a 26-page booklet describing the electrical and electronic properties of eighteen high nickel alloys. Designed primarily for electrical engineers, it cites typical uses of these metals, their mechanical and other properties and the various forms in which they are available.

Flexible Metal Hose

Chicago Metal Hose Corp. has issued a new 70-page illustrated catalog (G-50) containing descriptions and specifications for standard types of metallic hose in a variety of metals. In addition it contains sections on expansion joints for piping systems, stainless steel and brass elbows and various conduits and special assemblies of these components. The catalog is intended to give persons interested in metal hose products one self-contained source of information for various requirements.

Industrial Turbines

Recently released by the Westinghouse Electric Corp. is a 20-page booklet B-3896, which contains basic information on Type E industrial turbines. Cutaway views show operating features and general construction. Various wheel sizes are enumerated, and a guide is given to aid in selecting the proper turbine for particular loads and steam conditions.

Jaw Crushers

The Pennsylvania Crusher Co. has just published a comprehensive 12-page bulletin covering their line of "Kue-Ken" jaw crushers for use with a variety of products at mine, quarry and industrial operations. Basic principles of developments in jaw crushing are illustrated, and features of models currently being manufactured are explained. Installation data, details of construction and a table of capacity ratings with related information are all a part of the bulletin.

Lining and Insulation

The M. H. Detrick Co. has recently issued a 4-page bulletin illustrating insulation construction for flues, ducts and breechings. Methods of applying the material are explained and procedures for estimating and ordering are set forth.

Refractories

The Carborundum Co. has released an attractive 32-page bulletin illustrating its line of super refractories for boiler furnaces. Product characteristics are explained, and curves showing physical characteristics are plotted. Of particular interest are 23 colored cut-away views of various types of steam generating equipment showing refractory applications. There are also dimensioned photographs of representative types of brick and a table of refractory cements required for different uses.

Rust Inhibitor

Technical Bulletin No. 3, published by the Alox Corp., indicates physical properties and uses of two polar-type rust inhibitors, Alox 350 and 361, which are solids and liquids, respectively. Typical results obtained from laboratory tests are set forth, and recommended uses are listed. These include combination in solution with slushing oils, hydraulic oils, gear oils, automotive oils, fuel oils and turbine oils. Blending procedures are also explained in the 6-page bulletin.

Relief Valves

Bulletin 711 which contains information on forged steel relief valves has been issued by Edward Valves, Inc. Information on valve dimensions and weights, design detail and correct installation is included. Nominal design conditions for steam, oil or vapor are 600 psi at 850 F, but the relief valves can be furnished with special carbon springs for more severe service conditions.

Shutters and Penthouses

A 4-page descriptive bulletin on self-closing, manually-operated and motor-operated shutters has been issued by the L. J. Wing Mfg. Co. Typical dimensions are included for these shutters and for penthouses designed to provide ventilation directly through the roof of a building.

Strainers

Recently released by Edward Valves, Inc., is a 4-page bulletin providing information on forged steel strainers having an A.S.A. rating of 600 lb at 850 F for steam, oil or vapor. Data on dimensions and weights, correct installation, maintenance and cleaning are included.

Synchronous Motors

Bulletin PB 5600-1, describing Fabri-Steel, high-speed synchronous motors has just been issued by the Elliott Co. Construction features and mechanical modifications are illustrated in the 4-page release.

Tube Cleaners

Disassembled views of motors, circular and expanding brushes, and cutter and scraper heads for tube cleaners are illustrated in Bulletin Y-24 recently released by the Elliott Company's Lagonda Division. These cleaners may be driven by air, water or steam and are intended for use in straight or curved small tubes. A size tabulation is also included in the 4-page bulletin.

Turbo Pumps

Several lines of standardized steam turbine centrifugal pump and governor sets are described in a 4-page bulletin recently issued by The J. S. Coffin, Jr., Co. Constructed as integral units, including turbine, pump and governor, the high-speed, single-stage designs are intended for use in boiler feed service, for fuel oil, condensate return and evaporator feed, for hydraulic presses and in the petroleum industry. Features of the pumps are explained and cross-sections, including governor details, are shown.

BOOKS

1—Gas Tables

By Joseph H. Keenan and Joseph Kaye

238 pages Price $5.00

Professors Joseph H. Keenan and Joseph Kaye of the Massachusetts Institute of Technology have revised their earlier book entitled "Thermodynamic Properties of Air," which was published in 1945, and have reissued it under the title of "Gas Tables." The new edition contains 64 tables covering such physical conditions and concepts as air at low pressure; products of combustion of hydrocarbon fuels with 200 and 400 per cent of theoretical air; nitrogen, oxygen, water vapor, carbon monoxide and dioxide, hydrogen and argon, respectively, at low pressures; one- and two-dimensional isentropic compressible-flow functions; Rayleigh lines; Fanno lines; one-dimensional normal-shock functions; wedge angles for downstream sonic flow; upstream and downstream Mach numbers for two-dimensional shock; and various conversion factors.

Values for the thermodynamic properties of the gases were calculated and published by Johnson, Giauque, Gordon and Kassel in the years 1933 to 1935. These results were interpolated by Heck and more recently have been reviewed by F. D. Rossini and his colleagues of the Bureau of Standards in terms of the latest values of the fundamental constants and newest spectroscopic data. It is the last-mentioned information that serves as the basis of the thermodynamic properties of this new book.

2—Air Conditioning

By Herbert and Harold Herkimer

692 pages Price $12

Intended primarily for engineers concerned with air-conditioning application, this book touches upon various phases of that industry, such as design, estimating, sales, installation, supervision, service, etc. It reviews the laws of chemistry and physics associated with air conditioning and contains chapters on such subject as heat transfer, radiant heating, elementary thermodynamics, water vapor mixtures, fans, ducts and air distribution, heating and cooling loads, dehumidification, cooling towers, drying systems, air conditioners, automatic controls. Also included are application diagrams, numerous charts and tables and problems with their solutions.

3—Standards on Coal and Coke

163 pages Price $2.00

Some 29 standard specifications and tests covering coal and coke, as issued by the A.S.T.M., are published in a special compilation of 163 pages. They are as of September, 1948, and incorporate changes made during the current year, plus new material.

Test methods and procedures pertaining to coal cover, sampling, analysis for volatile in connection with smoke ordinances, grindability, drop shatter test, tumbler test, screen analysis, size, sieve analysis, cubic foot weight, index of dustiness, and free-swelling. Specifications cover classification by rank and grade.

For coke there are methods for sampling, and tests for volume of cell space, drop shatter, tumbler, sieve analysis, and cubic foot weight. Included are a number of definitions.

An Appendix contains proposed methods which the Committee is now studying involving: test for expansion pressure of coal during coking; test for plastic properties of coal by the Davis plastometer; test for plastic properties of coal by the Gieseler plastometer; test for carbonization pressure of bituminous coal; measurement of pressures developed during carbonization by the movable wall oven; expansion properties of coal for use in by-product coke ovens; test for pressures, strains, and other properties developed during carbonization; and test for agglutinating value.

4—Engine Room Questions and Answers

By Alex Higgins

154 pages 9×11 Price $4.00

This is a companion book to the author's previously published volume on boiler room practice. Employing the "question-and-answer method" its principal purpose is to assist those preparing for an operator's license by acquainting them with the principles underlying the construction and operation of engine-room equipment. More than half the text is devoted to steam engines of various types, and the remainder to steam turbines, condensers, bearings and lubrication.

5—Refresher Notes (Revised)

By John D. Constance

178 pages $8^3/_4 \times 11^1/_4$ Price $4.50

These notes, covering hydraulics, thermodynamics and machine design, form the basis of a tested course the author has given for several years past under the educational auspices of the Metropolitan Section A.S.M.E. Presenting the fundamental concepts, methods and applications of these subjects, the text is arranged as a review for those who have previously studied the subjects, and particularly to aid those who contemplate taking the examination for a professional engineer's license. In fact, most of the problems and their solutions are based on such past examination questions.

The book is in loose-leaf form, with paper cover, and the notes are offset. This revised edition contains a Mollier chart.

6—Smoke

By Arnold Marsh

306 pages Price $7.00

In view of the present renewed agitation for cleaner atmospheres in many of our cities, publication of this book is timely. Its author is secretary of the National Smoke Abatement Society of Great Britain and is therefore well informed on the subject.

The text is divided into two parts, the first dealing with certain fundamentals of combustion; smoke as a health problem; how it affects plant life; its destruction of property; its social aspects; and cost. Part II deals with what has been accomplished toward smoke abatement; the problem of both industrial and domestic smoke; suggested measures for its abatement and plans for progressive action. Air pollution from road vehicles, industrial fumes and dust is also discussed and a brief review is given of what has been done in various countries. The numerous illustrations have been well chosen to demonstrate the destructive action of smoke.

Those concerned directly or indirectly in smoke abatement will find a perusal of the book both interesting and helpful.

COMBUSTION PUBLISHING COMPANY, Inc., 200 Madison Avenue, New York 16, N. Y.

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